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REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR THE CONRAIL SITE ELKHART, INDIANA

FEASIBILITY STUDY REPORT

ARCS CONTRACT NO. 68-W8-0086
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Prepared for:

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LIST OF ACRONYMS

The following acronyms are used throughout the Feasibility Study Report.

ARARs	Applicable or relevant and appropriate requirements
ARCS	Superfund Alternative Remedial Contracting Strategy
BGS	Below ground surface
CAA	Clean Air Act
CCl_4	Carbon tetrachloride
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund)
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program (EPA)
CWA	Clean Water Act (1977)
DNAPL	Denser-than-water nonaqueous phase liquid
DNR	Department of Natural Resources (Indiana)
E & E	Ecology and Environment, Inc.
EPA	United States Environmental Protection Agency
ERT	Emergency response team
FS	Feasibility study
GRA	General Response Action
HSWA	Hazardous and Solid Waste Amendments of 1984
IAC	Indiana Administrative Code
IDEM	Indiana Department of Environmental Management
KPEG	Potassium polyethylene glycolate
LT^3	Low temperature thermal treatment
LTTA	Low temperature thermal aeration
MCL	Maximum contaminant level

List of Acronyms (Cont.)

MCLG	Maximum Contaminant Level Guidelines
MSL	Mean sea level
NCP	National Oil and Hazardous Substances Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O & M	Operation and maintenance
OAM	Office of Air Management
OSHWM	Office of Solid and Hazardous Waste Management
OSWER	Office of Solid Waste and Emergency Response (EPA)
OWM	Office of Water Management
PCB	Polychlorinated biphenyl
PCP	Pentachlorophenol
PFS	Phased feasibility study
POTW	Publicly owned treatment works
RAO	Remedial action objective
RCRA	Resource Conservation and Recovery Act of 1976
RI	Remedial investigation
RI/FS	Remedial investigation/feasibility study
RME	Reasonable maximum exposure
ROD	Record of Decision (EPA)
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SOW	Scope of work
TAT	Technical Assistance Team
TBC	To be considered
TCE	Trichloroethylene
TCLP	Toxicity characteristic leaching procedure
TSCA	Toxic Substances Control Act
USATHAMA	United States Army Toxic and Hazardous Materials Agency
UV	Ultraviolet
VOC	Volatile organic compound

1. INTRODUCTION

This Feasibility Study (FS) Report was prepared by Ecology & Environment, Inc. (E & E), to document the process through which remedial alternatives were identified, developed, and evaluated for the Conrail Site, located in Elkhart, Indiana. The United States Environmental Protection Agency (EPA), under the Region V Alternative Remedial Contracting Strategy (ARCS) Contract Number 68-W8-0086, directed E & E to conduct a Remedial Investigation and Feasibility Study (RI/FS) for the Conrail Site under work assignment 01-5L7Y. The findings of the RI are documented in the *Remedial Investigation Report* (E & E 1993).

1.1 PURPOSE AND ORGANIZATION OF REPORT

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), authorizes EPA to conduct remedial planning activities at uncontrolled hazardous waste sites placed on the National Priorities List (NPL). Subpart F of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes methods and criteria for determining the appropriate extent of response authorized by CERCLA, as amended by SARA, and outlines procedures for determining the nature and extent of contamination at a site, as well as the appropriate considerations for remediation for the site. In accordance with CERCLA, SARA, and the NCP, EPA developed a program for remediation and enforcement response activities at selected uncontrolled hazardous waste sites. As part of this program, EPA tasked E & E with conducting a Feasibility Study (FS) that addresses permanent remedies for source/soil and groundwater contamination at the Conrail Site located in Elkhart, Indiana. The FS is based on the findings of the RI, presented in the

Remedial Investigation Report (E & E 1993), and guidance provided by EPA. The purpose of the FS is to ensure that suitable remedial alternatives are developed and evaluated for the site. The purpose of this FS Report is to provide EPA with relevant information regarding remedial alternatives so that an appropriate remedy can be selected.

This section of the FS Report (Section 1) describes the purpose of the FS and summarizes site background information gathered during the RI. The background information presented discusses site history and layout, geology, hydrogeology, the nature and extent of contamination, contaminant fate and transport, and results from a baseline risk assessment. More detailed site information can be found in the *Remedial Investigation Report* (E & E 1993). Section 2 presents the remedial action objectives, general response actions, and the identification and screening of technologies. In Section 3, technologies and process options that are determined to be suitable for implementation at the site are developed into remedial alternatives. Section 4 provides a detailed analysis of alternatives, intended to provide regulatory agencies with sufficient information to select a remedy for the site. Section 5 summarizes the findings of the FS, and Section 6 presents the conclusions and operational recommendations for the Conrail Site. Section 7 presents the references cited within this document. Appendix A is a glossary of specialized terms used in the FS.

1.2 BACKGROUND INFORMATION

1.2.1 Site Description and History

The Conrail Site is located approximately 1 mile southwest of the city of Elkhart, Indiana, as shown on Figure 1-1. The site consists of contaminated areas in the Conrail railyard, and adjacent areas extending to the northwest and northeast from the railyard. The site is bounded to the east by Nappanee Avenue, to the south by the southernmost property line of the Conrail railyard, to the west by Baugo Bay, and to the north by the St. Joseph River. The study area encompasses approximately 2,500 acres and includes the 675-acre Conrail railyard, as well as several light industrial properties located to the north and northwest of the railyard (see Figure 1-1). The study area also includes residential areas south of the St. Joseph River in which groundwater contamination has been identified based on analytical data from previous sampling efforts. The residential areas, designated as the County Road 1, La Rue Street, Vistula Avenue, and Charles Avenue areas, are located to the northeast and northwest of the Conrail railyard.

The Conrail Site study area is located in the floodplain of the St. Joseph River. Topography in the study area is relatively flat, with ground surface elevations varying from 760 to 725 feet above mean sea level (MSL). Elevations are generally highest on the Conrail facility. Elevations decrease as the ground surface slopes towards the St. Joseph River. The St. Joseph River is a mature, meandering river, which flows to the west and forms the northern border of the study area. The stage of the St. Joseph River, as measured by E & E at the Ash Road bridge as it crosses the river, ranges between 717 and 715 feet above MSL and the flow of the river is regulated by a hydroelectric plant located in Elkhart, Indiana, upstream of the study area.

Surface soils at the Conrail facility have been disturbed and no series is recognizable. Sixty-five percent of the surface material in the Conrail facility is composed of stone ballast and concrete (Jacobs 1987). Several features important in the daily operations of the Conrail facility are presented on Figure 1-2. The largest feature is the main classification yard, which consists of 72 tracks that are sequentially numbered from track 1 in the northernmost area of the classification yard to track 72 in the southernmost area of the yard. The 72 tracks are divided into eight groups of nine tracks per group. Rail cars are sorted and redistributed by decoupling trains at the hump tower and, through gravity-driven coasting, subsequently recoupling cars by collision once they are directed to the appropriate track. Three ponds are located south of the classification yard on the Conrail facility. The hump tower is located east of the main classification yard. The receiving yard is a collection of tracks that extends from the hump tower eastward toward and past Nappanee Street. Another set of tracks, north of the main classification yard, contains a main line that handles through-traffic. A turnaround track is present between the main classification yard and the receiving yard. A diesel shop is located northeast of the main classification yard and west of the turnaround track. A car shop is located in the west end of the main classification yard, near its north-south center point. The Bridges and Buildings (B and B) Shop is located west and slightly south of the car shop.

The Conrail railyard began operations in 1956 as part of New York Central Railroad, and continued operations as a subsidiary of Penn Central Transportation Company. In April 1976, Penn Central Transportation Company transferred its railroad operations to Consolidated Rail Corporation (Conrail). In October 1978, Penn Central Transportation finalized a reorganization plan that transferred all of its rail assets to Conrail. The Conrail railyard currently serves as a classification and distribution yard for freight cars and is the primary connection between the Chicago area and Conrail's northeastern rail system.

From July to September 1986, investigations of the study area were conducted by the EPA Technical Assistance Team (EPA/TAT), the EPA Emergency Response Team (EPA/ERT), and Peerless-Midwest, Inc. Carbon tetrachloride (CCl_4), trichloroethene (TCE), and other volatile organic compounds (VOCs) were detected in groundwater samples collected during these investigations. As a result, bottled water and activated carbon filter units were provided/installed to residents whose wells were affected.

Beginning in July 1989, E & E conducted a Phase I RI at the Conrail Site. Following an evaluation of the data collected during the Phase I RI, E & E recommended, and EPA concurred, that a second phase of investigation be conducted to address project objectives. E & E completed a Phased Feasibility Study (PFS) in April 1991 (E & E 1991). A Record of Decision (ROD) for interim groundwater remedial action at the Conrail Site was signed in June 1991, selecting a remedy that followed the findings presented in the PFS. On July 7, 1992, EPA issued a Unilateral Administrative Order for Remedial Design and Remedial Action, which binds Conrail and the Penn Central Transportation Corporation to perform remedial activities described in the Statement of Work (SOW) attached to the Order. The interim remedial action for the Conrail Site, as described in the SOW, will consist of the following elements:

- Institutional Controls including deed restrictions for future use of the railyard executed through the Elkhart County Recorder; restrictive covenants ensuring that property outside the Conrail railyard on which components of the remedy will be located (e.g., monitoring wells, treatment facilities) will not be disturbed; and abandonment of residential wells located within the area of contamination;

- Monitoring Program including groundwater monitoring in and around the area of contamination and air monitoring of the treatment system;

- Groundwater Extraction, Collection, Treatment, and Discharge System will be designed, constructed, operated, and maintained to prevent further horizontal and vertical migration of contaminated groundwater located northwest, downgradient from the Conrail railyard by extracting water from the plume, treating it using air stripping, and discharging it to the St. Joseph River;

- Fence Installation to enclose groundwater extraction and treatment facilities; and

- <u>Provision of an Alternate Water Supply</u> through the design, construction, and first-year operation and maintenance of a distribution system extending from the City of Elkhart water supply to affected residential/business areas located downgradient from the Conrail railyard, and maintenance of individual water filter units or provision of bottled water for those areas until the distribution system is operational.

Conrail has retained a contractor to design and implement the interim groundwater remedial actions outlined in the SOW.

Beginning in July 1991, E & E conducted the Phase II RI at the Conrail Site. In July 1992, E & E submitted the *Conrail RI/FS, Phase II Technical Memorandum* to EPA (E & E 1992). The *Phase II Technical Memorandum* summarized, integrated, and presented interpretations and conclusions of data gathered during Phase I and Phase II field investigations. E & E recommended, and EPA concurred, that a third phase of investigation be conducted to further define the extent and/or pathways of known contamination sources and plumes and to investigate other potential source areas of contamination. The findings of the Phase III RI are presented in the Remedial Investigation Report (E & E 1993).

1.2.2 Site Geology and Hydrogeology

The information collected by E & E during the subsurface investigations is used to describe geological conditions present in the study area. The 52 soil borings and 77 boreholes for monitoring well installation allowed for extensive coverage, with respect to area and depth, of the study area. The combined results of the subsurface soil investigations that were conducted during the three phases of the RI show that the study area primarily consists of unstratified sand and gravel glacial outwash deposits. Evaluation of the subsurface soil investigation findings also show that silt and clay units are present as discrete and isolated lenses or masses.

The bedrock units beneath the overburden consist of the Coldwater Shale of Mississippian age and the Sunbury and the Ellsworth Shales of Devonian and Mississippian age (Imbrigiotta and Martin 1981). Shale was encountered and sampled while drilling at seven locations and in all cases the shale was bluish-gray to greenish-gray, pristine, dry, and extremely dense. The approximate thickness of this overburden ranges from 137 to 169 feet and the median depth to bedrock is 150 feet BGS. The median elevation of the bedrock surface is 600 feet above MSL and is essentially horizontal under the study area. Because the bedrock is not an aquifer and was observed to be pristine, dry, and extremely dense, the investigation and analysis will focus on the glacial geology.

The depth to the water table in the study area varies from approximately 3 feet BGS to nearly 20 feet BGS. The observed depth to water depends on geographic location, season, and elevation of the ground surface. A comparison of the data recorded during at least 14 separate monitoring events over a three-year time span indicates fluctuations of less than 3 feet observed in the elevation of the potentiometric surface. The relative static water levels among wells were consistent for each monitoring event, causing the shape of the potentiometric contour lines and horizontal groundwater gradients to remain constant in the shallow zone (the water table to approximately 35 feet BGS), the intermediate zone (35 feet BGS to 85 feet BGS), and the deep zone (85 feet BGS to the top of bedrock). The median Phase III horizontal groundwater gradient is 0.0020 ft/ft for the shallow zone, 0.0019 ft/ft for the intermediate zone, and 0.0020 ft/ft for the deep zone. The general groundwater flow direction in all zones is to the west-northwest. In the LaRue Street area, however, the general flow direction is north.

The vertical hydraulic gradients calculated between two wells at various nested locations show a general downward gradient in the study area. The vertical hydraulic gradients and the respective locations of the monitoring well nests in the study area are consistent with groundwater recharge in the railyard and subsequent groundwater discharge to the St. Joseph River.

Hydraulic conductivity values were calculated from slug test data collected during the Phase II investigation, and correspond to the filter pack and aquifer material immediately surrounding the screened interval of the tested well. As a basis for comparison, a hydraulic conductivity value was also derived from the pump test conducted in the study area by a water supply contractor (Peerless-Midwest, Inc. [no date]). A hydraulic conductivity value calculated from a pump test represents the hydraulic conductivity of the aquifer material within the zone of influence of the pumping. Because of the heterogeneity of the aquifer, variation between slug test data and a large-scale pump test's data within one or two orders of magnitude is not unusual. The geometric mean of E & E's Phase II slug test results gives a hydraulic conductivity value of 69 feet per day. The Peerless-Midwest pump test result gives a hydraulic conductivity value of 280 feet per day. The heterogeneity in site conditions caused variability in input parameters that result in a velocity range for groundwater of 11 feet per year to 2,200 feet per year. The mean horizontal flow velocity of groundwater, based on a hydraulic conductivity of 69 feet per day, a horizontal gradient of 0.0020, and an effective porosity of 0.25, is 200 feet per year.

1.2.3 Nature and Extent of Contamination

This section discusses the nature and extent of soil and groundwater contamination. Discussion of source areas is based on analytical results from Phase I, II, and III soil samples.

1.2.3.1 Soil Contamination

Fifty-two soil borings, along with subsurface soil sample collection, were completed during three phases of field investigation in order to determine the nature and extent of identified and suspected source areas contributing to identified groundwater contamination. Figure 1-3 shows the soil boring locations. Based on analytical results from subsurface soil samples, two well-defined source areas on the Conrail facility have been identified that contain significant levels of contamination. A third potential CCl_4 source area with lower levels of contamination has been identified in the eastern portion of the Conrail railyard.

A CCl_4 source area was identified in the eastern section of the classification yard based on subsurface soil samples from soil borings B-03, B-24, B-25, B-26, B-40, B-41, and B-42. Based on analytical data from soil samples collected from these borings, CCl_4 contamination was detected in an area bounded on the west and east by B-24 and B-25, respectively (75 feet), and on the north and south by B-41 and B-42, respectively, (30 feet). CCl_4 contamination was detected in soil samples collected from these borings between the depths of 18 feet BGS and 25.5 feet BGS (7.5 feet). The analytical data from these boundary locations are greater than or equal to 1 mg/kg, suggesting that this CCl_4 source area extends beyond the approximate boundaries established with the data to date. This source is located in the saturated zone, in a stratigraphic unit that is more silty than the stratigraphic units above and below it. B-40 was drilled to the top of bedrock (150 feet) and soil samples were collected throughout the length of the borehole. CCl_4 was detected only once between 58 feet and 150 feet BGS at 16 μg/kg in the 128 to 130-foot interval sample. Chloroform, a degradation product of CCl_4, was also detected in this interval at a concentration of 9 μg/kg. Groundwater data (see Section 4.3) and site background information indicate the presence of a CCl_4 dense non-aqueous phase liquid (DNAPL) source. DNAPL chemicals are immiscible with and denser than water. Their immiscibility and high density enable DNAPL constituents released to a porous medium to penetrate the unsaturated zone and migrate downward into the saturated zone as a separate nonaqueous phase. This nonaqueous phase may persist as pooled product accumulated on a stratigraphic unit or as residual material throughout the vertical column of the unconsolidated deposit.

A TCE source area was identified in the western section of the classification yard, approximately 1,900 feet west of the eastern straight-a-way between tracks 65 and 66. Approximate dimensions of this source area are based on analytical data from subsurface soil samples collected from soil borings B-27, B-28, B-29, B-32, B-47, B-51, and B-52. TCE contamination was detected in an area bounded on the west and east by B-29 and B-32, respectively (120 feet), and on the north and south by B-47 and B-28 (10 feet). TCE contamination was detected in soil samples collected from these soil borings at depths from 0 feet to 4 feet BGS. This TCE source area is located in the unsaturated zone. However, groundwater data from wells located directly downgradient from this source (MW49D and MW49BR) detect TCE contamination at depths much greater than 4 feet BGS, indicating unidentified TCE contamination deeper in the subsurface or an unidentified DNAPL TCE source.

In the eastern portion of the site, CCl_4 contamination was detected in subsurface soil samples collected from soil borings B-48, B-49, and B-50 located on an east-west-trending line, just north of track 6 in the receiving yard at the eastern end of the site, on the Conrail facility in the LaRue Street area. The contamination in soil samples in this area is of low concentration ($\leq$31 μg/kg CCl_4), yet the CCl_4 groundwater contamination in the LaRue Street plume is also of low concentration. CCl_4 was detected in the 0 to 2-foot BGS sample interval in soil boring B-50. Although the concentrations of CCl_4 detected in the soil samples do not definitely define a source area, they do indicate the presence of surface and subsurface CCl_4 contamination potentially contributing to groundwater contamination.

1.2.3.2 Groundwater Contamination

Seventy-seven monitoring wells were installed during three phases of field investigation. Figure 1-4 presents the locations of the monitoring wells and the analytical results of the most recent round of groundwater sampling.

CCl_4 and TCE contamination were detected in groundwater samples collected from monitoring wells screened in the shallow, intermediate, and deep zones on the Conrail facility, at the St. Joseph River, and in the area between these points. Groundwater flow direction in all three zones is west-northwest, and the County Road 1 groundwater contamination plume as defined by groundwater samples follows this path from the Conrail facility to the St. Joseph River. Groundwater in the LaRue Street area flows to the north. Based on groundwater flow direction, groundwater samples collected from monitoring wells located hydraulically upgradient of the plume and on the Conrail facility, MW27S and I, MW28S and I, MW29S and I, and MW31S and I, and groundwater samples from monitoring wells MW13S and D, located upgradient of the plume and the site, did not detect any VOC contamination.

The maximum concentration of CCl_4 groundwater contamination was 110,000 $\mu g/L$ collected from monitoring well MW46S located in the track 69 source area. This concentration is 13.8% of the solubility of CCl_4 and suggests a CCl_4 DNAPL source (EPA 1992). Site background information and the detection of CCl_4 in a subsurface soil sample at 130 feet BGS also suggest that the CCl_4 source area in track 69 is a DNAPL source.

The maximum concentration of TCE detected in a groundwater sample was 11,000 $\mu g/L$ from monitoring well MW41, located immediately downgradient of the Conrail facility. This concentration is 1.4% of the solubility of TCE and suggests a TCE DNAPL source (EPA 1992). MW41 is side-gradient of the TCE source area identified in the classification yard. Based on analytical and hydrologic data, the DNAPL source is on the Conrail property, but is, as yet, unidentified.

CCl_4 was detected only in groundwater samples collected from shallow monitoring wells in the LaRue Street plume surrounding the identified CCl_4 soil contamination in the receiving yard on the Conrail facility. The soil contamination is thought to contribute to the identified Ccl_4 groundwater contamination. Monitoring wells upgradient of the soil contamination did not detect CCl_4.

TCE was detected only once (MW20S - 15 $\mu g/L$) above the maximum contaminant level (MCL) for TCE (5 $\mu g/L$) in the LaRue Street plume. TCE was detected below the MCL throughout the plume. Monitoring wells located upgradient of the Conrail facility did not detect TCE. Based on groundwater analytical data, the source of the TCE contamination is on the Conrail property, but is, as yet, unidentified.

1.2.4 Contaminant Fate and Transport

The RI Report presented a site-specific analysis of the fate and transport processes likely to be operating at the site. This analysis was conducted to estimate the mass of CCl_4 and TCE in the study area and loading to the St. Joseph River.

A focused discussion on the subsurface and groundwater fate and transport of CCl_4 and TCE is presented in this subsection. Processes such as volatilization, liquid transport, sorption, and transformation reactions have likely occurred at the site based upon the contaminants present and the observed environmental conditions. Volatilization of the dissolved chlorinated aliphatic hydrocarbons from the groundwater that are present at or near the water table can transfer significant contaminant mass from groundwater to soil gas. There is a high probability that this process has occurred and is currently operative in the study area. Liquid transport is occurring at the site as dissolved contaminants in groundwater undergo migration. If DNAPL is present, it may also migrate by density driven-liquid transport processes specific to DNAPLs. Sorption of chemicals of potential concern onto aquifer materials is expected to be an important process at the site. Analytical results of total organic carbon in the aquifer material are combined with chemical-specific data to quantify sorption so that retardation can be estimated. The retardation is used to estimate the migration rate of contamination relative to the groundwater flow velocity. Of the numerous transformation reactions that may possibly occur, sequential reductive dehalogenation is important because it appears to be functioning at the site.

The fate and transport processes coupled with site-specific data enable the estimation of movement, mass, and loading of CCl_4 and TCE. The heterogeneity in site conditions causes a large range in the time (6 to 1,200 years) estimated for groundwater to travel from the source areas to the St. Joseph River. If retardation does not take place, contamination would undergo advection at the same rate as groundwater flow. If available sorptive capacity in the aquifer materials permits sorption, it is estimated that CCl_4 and TCE will travel at approximately 40 percent of the rate of groundwater. The total mass of CCl_4 and TCE remaining in the aquifer as dissolved contaminants in the groundwater and sorbed to aquifer materials can be estimated based on analytical data from the site and an estimate of DNAPL volume. The estimated total mass of CCl_4 and TCE in the groundwater and sorbed to aquifer materials is 20,000 pounds. Of this 20,000 pounds, it is estimated that 8,000 pounds exist as dissolved contaminant mass in the groundwater. Residual DNAPL may contribute 150,000 pounds as CCl_4 and TCE, combined. The estimated loading from the site to the St. Joseph River is 20 pounds of TCE and 20 pounds of CCl_4 per year. Assuming this loading, it would take 200 years to remove the CCl_4 and TCE that is dissolved in the groundwater presently in the aquifer. If DNAPL is present, this estimate of elapsed time for natural attenuation would be much greater.

Transformation reactions resulting in the formation of daughter products of CCl_4 and TCE are occurring at the site. The daughter compounds chloroform and 1,2-dichloroethene (total) were detected in monitoring well samples that also contained higher concentrations of CCl_4 and TCE, respectively.

1.2.5 Human Health and Ecological Risk Assessment

Based on the findings of the RI, a baseline risk assessment was performed to evaluate the risks posed to human health and the surrounding ecological environment by site contamination. The objective of this risk assessment was to identify potential pathways of exposure for human and environmental receptors as well as to estimate, quantitatively, the exposures that could occur and the risks associated with such exposures. The findings of this assessment, in addition to the procedures, methods, and assumptions used during the risk assessment process, are described in detail in the *Remedial Investigation Report* (E & E 1993). The risk assessment determined that site contamination does not pose significant risks to ecological receptors (e.g., sensitive species), but does pose significant risks to human health. This section presents a concise summary of the findings of the human health risk assessment that are relevant to site remediation.

The risk assessment identified and focused on the following source areas for the Conrail Site:

- VOC contamination in the groundwater and subsurface soil beneath the railyard.
- VOC contamination of groundwater in the County Road 1 Plume area, extending north and west from the central portion of the railyard. This plume potentially affects an area that encompasses the County Road 1, Charles Avenue, and Vistula Street residential areas.
- VOC contamination of groundwater in the LaRue Street Plume area, extending north from the eastern portion of the railyard. This plume potentially affects the LaRue Street residential area.

From these source areas, the risk assessment identified the following exposure pathways that appear to have the greatest potential to produce adverse human health effects: direct contact with contaminated soil or groundwater (dermal contact or accidental ingestion) and inhalation of contaminants volatilized from the soil or groundwater. This risk assessment quantitatively evaluated two groups of receptors; adult workers and visitors exposed to existing site conditions, and local residents of potentially affected areas. The risks to the site workers and visitors consist of inhaling contaminants volatilized from groundwater and subsurface soils, and possible direct contact during any excavation activity in contaminated areas.

The risks to the residents in the areas of the County Road 1 Plume and LaRue Street Plume are from ingestion, dermal exposure, and vapor inhalation of groundwater used for domestic purposes, and inhalation of compounds volatilized from the groundwater and infiltrating basements or other enclosed areas. It was assumed that there will be no change in use of the site in the foreseeable future, and no new residences constructed any closer to the site than already exist.

The risk assessment evaluated the following VOCs as contaminants of potential concern: acetone, 2-butanone, CCl_4, chloroform, chloromethane, 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, ethylbenzene, methylene chloride, methyl isobutyl ketone, tetrachloroethene, 1,1,2-trichloroethane, 1,1,1-trichloroethane, TCE, toluene, vinyl chloride, and xylenes. Of these contaminants of potential concern, it was determined that CCl_4, chloroform, 1,1-dichloroethene, 1,2-dichloroethene, TCE, and vinyl chloride contribute significantly to human health risks. Both categories of human health risks, carcinogenic (cancer) and non-carcinogenic (e.g., organ immunological effects, birth defects, skin irritation), were evaluated. Some contaminants may pose both types of risks.

According to the risk assessment, contaminants in three areas at the site pose carcinogenic risks that exceed the 1×10^{-6} level established by EPA as a point of departure for determining protective cleanup levels. These areas and the contaminants that pose these risks include:

- The railyard area—due to subsurface soil contamination (vinyl chloride, and to a lesser extent TCE) and due to groundwater contamination (CCl_4, and to a lesser extent TCE).

- The County Road 1 Plume area—due to CCl_4, chloroform, 1,1-dichloroethene, TCE, and vinyl chloride in the groundwater.

- The LaRue Street Plume area—due to CCl_4, chloroform, and TCE in the groundwater.

Contaminants and exposure scenarios which pose significant carcinogenic risks are summarized in Table 1-1. The risks shown are for reasonable maximum exposure (RME) scenarios. The highest potential cancer risks are posed to residents in the County Road 1 Plume area due to ingestion of CCl_4 and TCE in groundwater.

The reduction of contaminant concentrations to levels at which they pose an excess lifetime cancer risk between 1×10^{-4} and 1×10^{-6} has been determined by EPA to be an acceptable cleanup level. On the basis of the results of the risk assessment, the more conservative risk (1×10^{-6} as established in the NCP as a point of departure for establishing cleanup levels) can be achieved by reducing the contaminant concentrations in on-site soils and in groundwater to the risk based concentrations shown in Table 1-1. However, the values presented in Table 1-1 represent the conservative end of the range (10^{-4} to 10^{-6}) of risks that are acceptable for cleanup levels. Values as high as 100 times the risk-based concentrations shown on Table 1-1 would still fall within the acceptable range.

The risk-based concentrations are calculated values based upon excess cancer risks determined to be posed by the RME input concentrations (derived in the risk assessment portion of the *Remedial Investigation Report* (E & E 1993)). The RME input concentrations, the resulting calculated cancer risks, and concentrations at which risks would be reduced to the 1×10^{-6} level are shown in Table 1-2. The calculated risk-based concentration for a chemical is derived by determining the factor by which the excess cancer risk is multiplicative of 1×10^{-6}. A proportional amount of the RME input concentration is determined using this same factor in order to obtain the risk-based concentrations. These calculations have been performed for each compound in each pathway and the results (risk-based concentrations) are listed in Table 1-1. Mathematically, this calculation is simply a normalization of the excess cancer risk to a value of 1×10^{-6} in order to convert the RME input concentration to the risk-based concentration. This risk is a factor of 2.58 larger than 1×10^{-6}. The calculation is performed by dividing the RME input concentration (in this example, 7,707 μg/kg) by the factor (2.58) to determine the risk-based concentration (2,990 μg/kg).

The assessment of non-carcinogenic risks determined that significant risks (hazard indices exceeding 1.0) were posed by CCl_4 and 1,2-dichloroethene as a result of groundwater use by residents in the County Road 1 Plume and LaRue Street Plume areas. In order to reduce the hazard indices below 1.0 (the level below which no adverse health effects are anticipated), contaminant concentrations must be decreased to the levels shown in Table 1-2. The risk-based concentrations listed in Table 1-2 were calculated using the same approach used in Table 1-1. The calculation performed in Table 1-2 involves different parameters due to the replacement of the excess cancer risk by the hazard index. The non-carcinogenic risk-based concentrations are calculated by determining the multiplying factors by which the hazard indices exceed the 1.0 benchmark.

In summary, by reducing site contaminant concentrations to the risk-based concentrations shown in Tables 1-1 and 1-2, residual contaminant concentrations would be unlikely to pose significant adverse health effects through the exposure pathways evaluated in the risk assessment. These values will be taken into consideration in Section 2.3 to help establish remedial objectives and specific cleanup goals.

Table 1-1

SUMMARY OF ESTIMATED EXCESS CANCER RISKS AND RESULTING RISK-BASED CONCENTRATIONS

Pathway	Chemical	RME Input Concentration[a]	Excess Cancer Risk	Risk-Based Concentrations[b]
On Site Worker Exposure (Soil)				
Inhalation	Trichloroethene	7,707 µg/kg	2.58E-06	2,990 µg/kg
	Vinyl chloride	8 µg/kg	1.02E-05	0.78 µg/kg
On Site Worker Exposure (Groundwater)				
Inhalation	Carbon tetrachloride	94,500 µg/L	4.15E-04	228 µg/L
	Trichloroethene	7,100 µg/L	3.81E-06	1,860 µg/L
Nearby Residential Exposure - County Road 1 Plume (Groundwater)				
Groundwater usage	Carbon tetrachloride	2,475 µg/L	5.46E-03	0.45 µg/L
	Chloroform	148 µg/L	1.56E-04	0.95 µg/L
	1,1-dichloroethene	48 µg/L	4.72E-04	0.10 µg/L
	Trichloroethene	13,000 µg/L	4.43E-03	2.9 µg/L
	Vinyl chloride	7 µg/L	1.80E-04	0.04 µg/L
Inhalation (indoor air)	Carbon tetrachloride	655 µg/L	1.59E-04	4.1 µg/L
	Chloroform	25 µg/L	1.12E-06	23 µg/L
	1,1-dichloroethene	8 µg/L	8.26E-06	0.97 µg/L
	Trichloroethene	93 µg/L	2.75E-06	34 µg/L
Nearby Residential Exposure - La Rue Street Plume (Groundwater)				
Groundwater usage	Carbon tetrachloride	76 µg/L	1.26E-04	0.60 µg/L
	Chloroform	5 µg/L	4.74E-06	0.95 µg/L
	Trichloroethene	10 µg/L	3.38E-06	3.0 µg/L
Inhalation (Indoor air)	Carbon tetrachloride	44 µg/L	1.06E-05	4.1 µg/L

[a] Derivation of these values is explained in the risk assessment portion of the *Remedial Investigation Report* (E & E 1993).
[b] Concentrations are calculated on the need to reduce excess cancer risk to 1.00E-06 for each compound.

Source: Ecology and Environment, Inc. 1994.

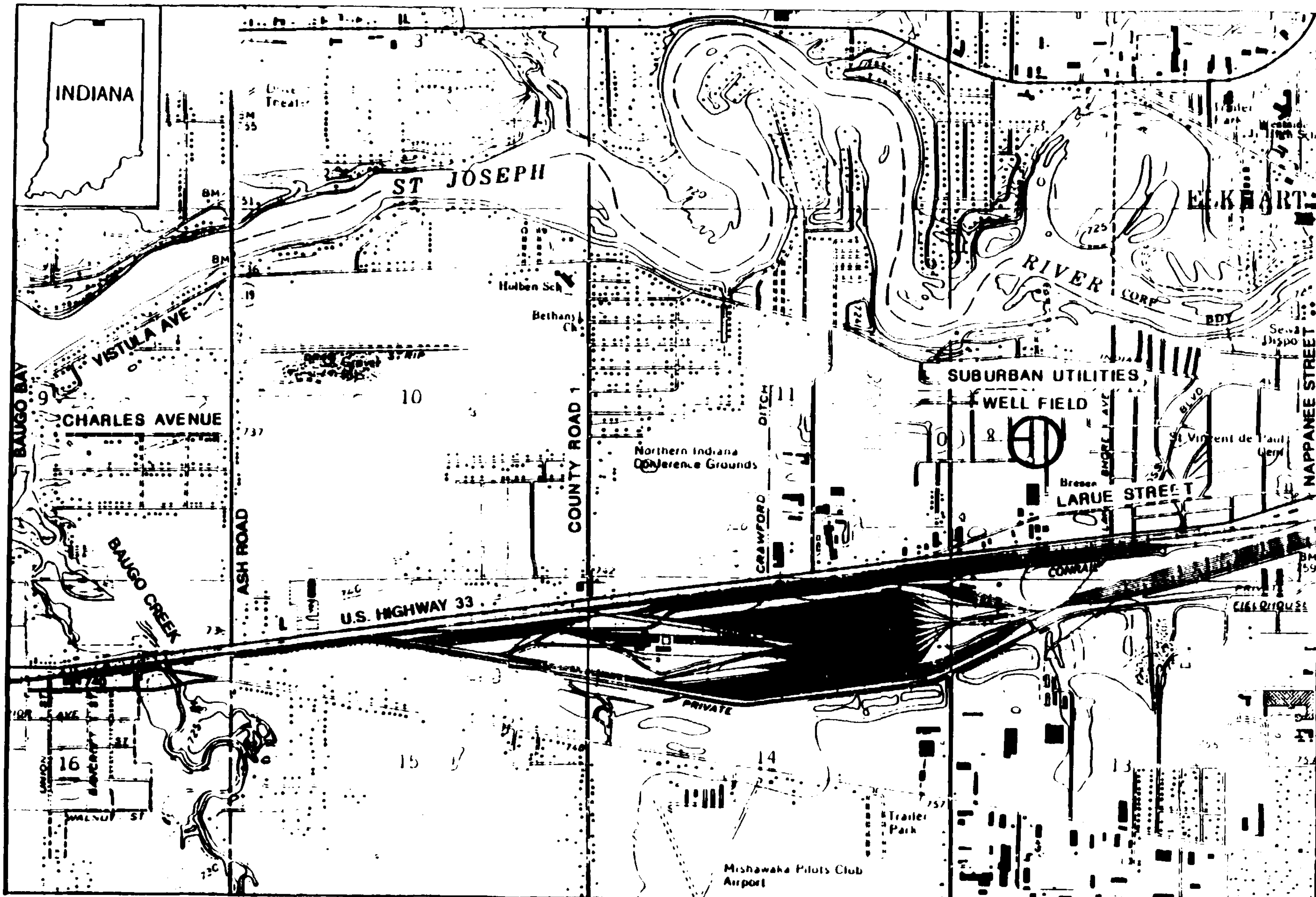
Table 1-2

SUMMARY OF ESTIMATED HAZARD INDICES AND RESULTING RISK-BASED CONCENTRATIONS

Pathway	Chemical	RME Input Concentration[a]	Hazard Index	Risk-Based Concentrations[b]
On Site Worker Exposure (Soil/Groundwater)				
Inhalation	Total	—	1.52E-02	—
Nearby Residential Exposure - County Road 1 Plume				
Groundwater usage	Carbon tetrachloride	2,475 µg/L	1.01E+02	25 µg/L
	1,2-dichloroethene	203 µg/L	1.23E-00	165 µg/L
Inhalation (indoor air)	Total	—	7.23E-02	—
Nearby Residential Exposure - La Rue Street Plume				
Groundwater usage	Carbon tetrachloride	76 µg/L	3.10E-00	25 µg/L
Inhalation (Indoor air)	Total	—	2.79E-03	—

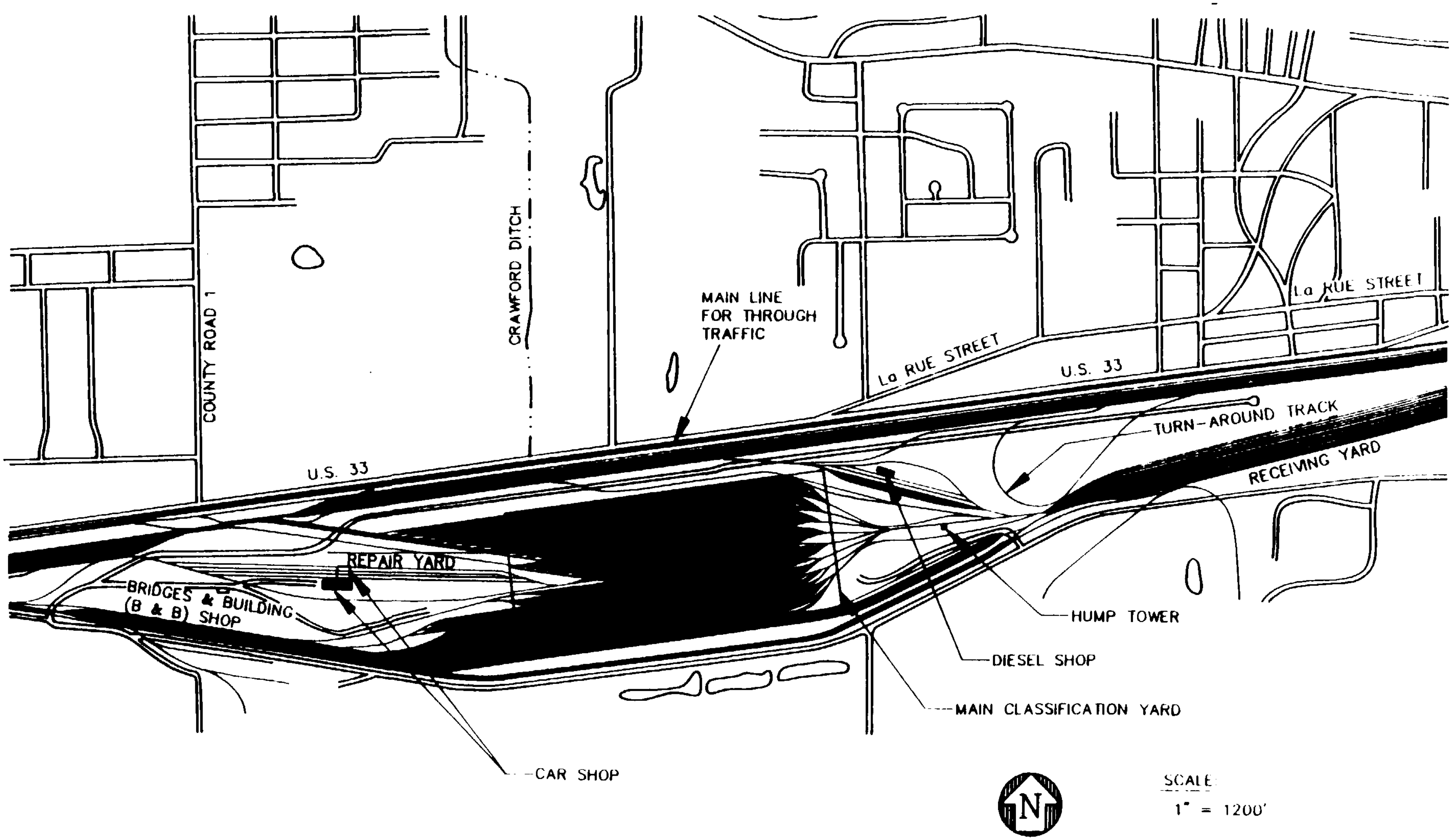
[a] Derivation of these values is explained in the risk assessment portion of the *Remedial Investigation Report* (E & E 1993).
[b] Concentrations were calculated on a need to reduce the Hazard Index to 1 for each compound.

Source: Ecology and Environment, Inc. 1994.



SOURCE: Ecology and Environment, Inc., 1993; BASE MAPS: USGS, Elkhart, IN Quadrangle, 7.5 Minute Series, 1961, Photorevised 1981; USGS, Osceola, IN Quadrangle, 7.5 Minute Series, 1969, Photorevised 1980.

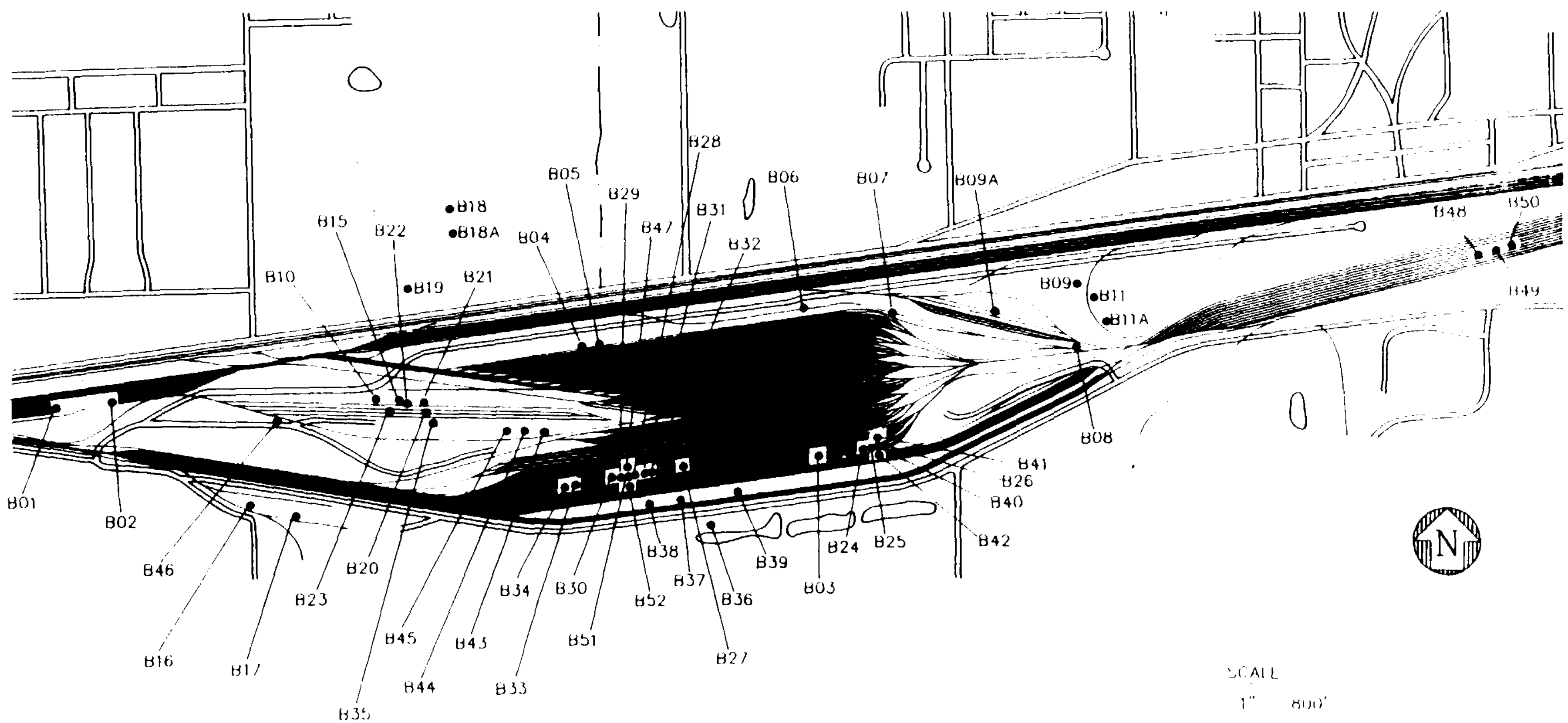
FIGURE 1-1 CONRAIL SITE STUDY AREA LOCATION MAP



ecology and environment, inc.

FIGURE 1-2
SITE FEATURES MAP

2F3FSFIG7



ecology and environment

FIGURE 1-3 REMEDIAL INVESTIGATION SOIL BORING

ZF3F5FIG6

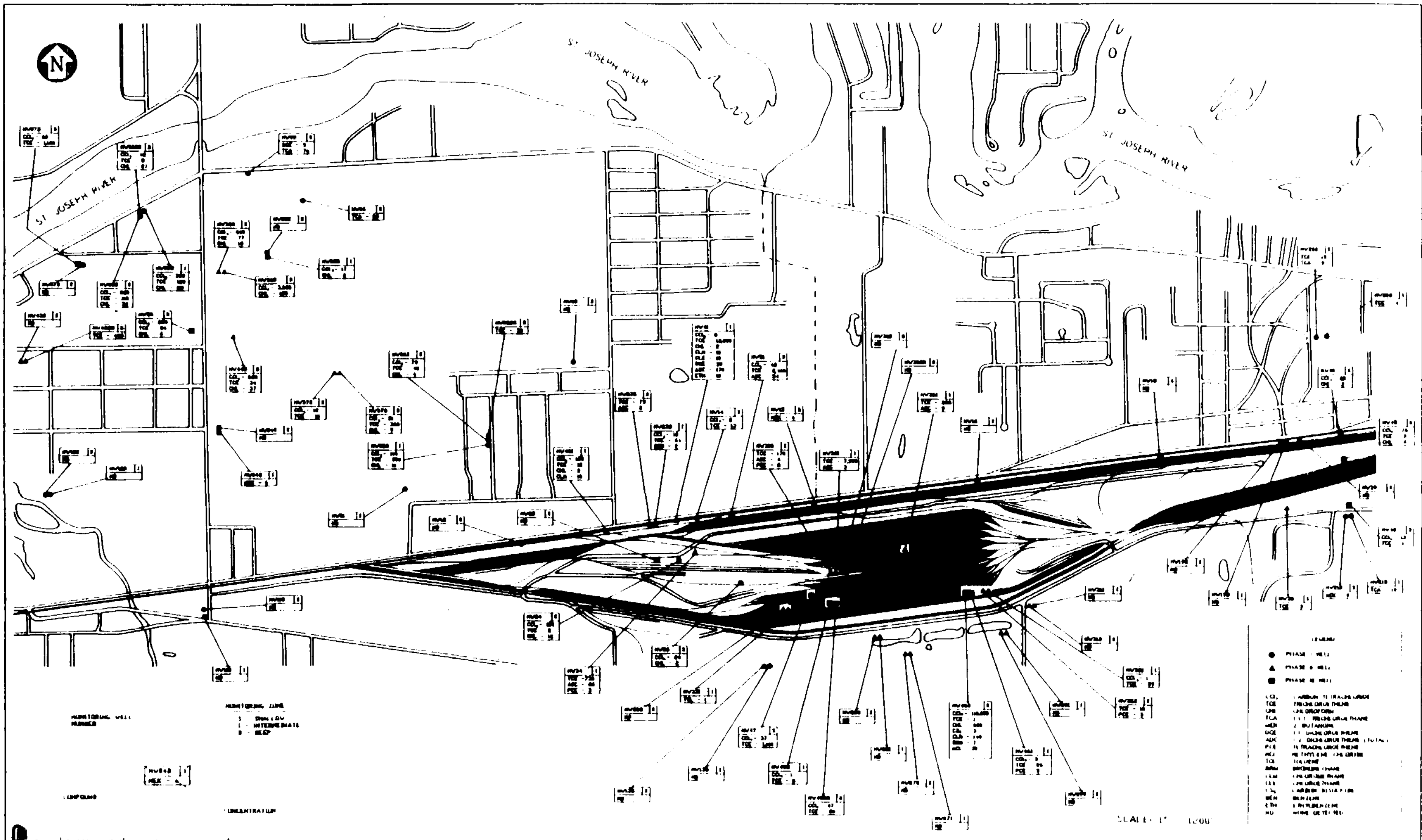


FIGURE 1-4 CONRAIL SITE MONITORING WELL

2. IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 INTRODUCTION

This section establishes the framework for the FS. First, remedial action objectives (RAOs) are established for the media and contaminants of concern, taking into account federal and state regulatory requirements and the findings of the site-specific human health and ecological risk assessment. General response actions describing measures that will satisfy the RAOs are then developed. Finally, remedial technologies applicable to each general response action are identified and screened, based upon technical implementability. Technologies retained after the screening process are evaluated on the basis of effectiveness, implementability, and, to a lesser extent, cost. Specific process options are selected for each technology, where appropriate. Using the technologies and process options retained from this evaluation, a range of remedial alternatives will be developed and subsequently screened in Section 3.

2.2 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are medium-specific goals for protecting human health and the environment. RAOs are established under the broad guidelines of meeting all applicable or relevant and appropriate requirements (ARARs). During the development of RAOs, other regulatory guidance and criteria to be considered (TBCs), and risk-based remediation goals are also evaluated to establish preliminary cleanup levels. The risk-based values are calculated by determining concentrations of contaminants that can remain on-site without posing an excess risk of cancer in the target populations of greater than one in a million (1×10^{-6}) or without posing other chronic health problems above an acceptable level (below a hazard index benchmark of 1). No significant risks to environmental receptors (e.g., sensitive ecosystems or species) were identified in the ecological assessment; therefore, protection of the environment c sts of protecting currently uncontaminated areas and restoring cont- nated areas.

Both -neral RAOs ar nedium-specific and chemical-specific cleanup goals have been established for the Conrail Site. General RAOs include:

- Minimizing potential for human exposure to contaminants by eliminating significant exposure routes and/or reducing contaminant concentrations;
- Minimizing further degradation of the groundwater within the aquifer beneath the facility;
- nizing fur degradation of the aquifer downgradient from the r y (outside he railyard property boundaries); and
- Res ing the groundwater within the aquifer to its original use as a drinking water source.

Numerical values that were considered for establishing specific preliminary remediation goals for individual contaminants in both soil and groundwater are summarized in Table 2-1. The following subsections discuss the ARARs, TBCs, and risk-based values that were considered to establish these numerical levels for the Conrail Site.

2.2.1 ARARs

Section 121(d) of SARA requires that remedial actions be consistent with and in accordance with other environmental laws. These laws may include: the Resource Conservation and Recovery Act (RCRA), the Clean Water Act (CWA), the Clean Air Act (CAA), the Toxic Substances Control Act (TSCA), and the Safe Drinking Water Act (SDWA), among other federal laws, and any state law that has stricter requirements than the corresponding federal law.

The regulations and standards preliminarily identified for the Conrail Site have been categorized as ARARs or TBCs. ARARs are legally binding, unless a waiver is obtained. While TBCs are not legally binding, they were considered along with ARARs during the development of RAOs.

ARARs may be further categorized as:

- Chemical-specific requirements that may define acceptable exposure levels and therefore be used in establishing preliminary remediation goals;
- Location-specific requirements that may set restrictions on activities within specific locations such as floodplains or wetlands; or
- Action-specific requirements that may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes.

Lists of federal ARARs and TBCs that have been identified for the Conrail Site are shown in Tables 2-2 and 2-3, respectively. State of Indiana ARARs and TBCs that have been identified for the Conrail Site are listed in Table 2-4. The chemical-specific ARARs and TBCs, which were considered for establishing RAOs for the site, are discussed within this section. Location-specific and action-specific ARARs and TBCs which are specific to various remedial alternatives, are discussed, where appropriate, in Sections 3 and 4.

The NCP states that, for groundwater that is a current or potential source of drinking water, remedial actions shall attain maximum contaminant level goals (MCLGs) established under the SDWA, if those levels are above zero. Where the MCLG has been set at zero, the maximum contaminant level (MCL) shall be attained. MCLGs are set forth in the SDWA, 40 CFR 141.50-141.52. MCLs are set forth in the SDWA, 40 CFR 141.11-141.16 and 141.60-141.63 and are presented in Table 2-1. Since the groundwater in the Conrail Site study area is currently used as a drinking water source, and has the potential to continue to serve as a drinking water source in the future, the MCLGs or MCLs were evaluated for use as cleanup goals for the contaminants of potential concern at the Conrail Site. For the contaminants of potential concern at the Conrail Site, all MCLGs are either zero or are the same level as the MCL for a particular chemical. Therefore, MCLs were considered for establishing cleanup goals.

The proposed RCRA corrective action regulations (set forth in 55 FR 30865, July 27, 1990) identify a number of "action levels" for contaminants of concern at the Conrail Site. For purposes of this FS Report, these action levels have been identified as TBCs because the regulations have not yet been finalized; furthermore, by definition these regulations are not intended to establish final cleanup goals, but rather the need for a RCRA corrective measures study.

Should meeting RAOs prove to be very difficult to achieve, ARARs may be able to be waived, and, subsequently, RAOs may be modified. Section 121(d)(4) of CERCLA identifies six circumstances under which ARARs may be waived:

- The remedial action selected is only a part of a total remedial action (interim remedy) and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- For §104 Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

The presence of DNAPL and unidentified source areas (suspected of being present beneath the railyard) may limit the technical feasibility of achieving some ARARs (e.g., reducing groundwater concentrations to attain MCLs beneath the Conrail railyard). Alternate cleanup levels (ACLs) may need to be established at a later date for contaminants that cannot practicably be reduced to the cleanup goals recommended herein. ACLs would most likely be applied only to certain areas that cannot practicably be remediated, while remaining areas would have to be remediated to meet RAOs.

2.2.2 Risk-Based Values

The risk assessment conducted for the Conrail Site was discussed in Section 1.2.5. Cleanup goals for specific media (i.e., groundwater or soil) necessary to reduce the excess risk of cancer to below 10^{-6} or to reduce the hazard index to below 1 were developed based on the findings of the risk assessment. These risk-based concentrations are required to be considered in the final remedy selection process by the National Contingency Plan (NCP) regulations set forth in 40 CFR 300.430 and EPA guidance (Office of Solid Waste and Emergency Response [OSWER] Directive 9355.0-30, April 22, 1991). These levels are presented in Table 2-1. The risk assessment indicated that potentially significant exposure routes include:

- Inhalation of vapors by site workers - volatilization of TCE and vinyl chloride from soil and CCl_4, TCE, and vinyl chloride from groundwater beneath the railyard;
- Groundwater usage by residents in the County Road 1 Plume area - ingestion, inhalation, and dermal contact with CCl_4, chloroform, 1,1-dichloroethene, TCE, and vinyl chloride in groundwater;
- Inhalation of vapors within buildings by residents in the County Road 1 Plume area - volatilization of CCl_4, chloroform, 1,1-dichloroethene, and TCE from groundwater;
- Groundwater usage by residents in the LaRue Street Plume area - ingestion, inhalation, and dermal contact with CCl_4, chloroform, and TCE in groundwater; and
- Inhalation of vapors within buildings by residents in the LaRue Street Plume area - volatilization of CCl_4 from groundwater.

Specific RAOs for the site have been developed that focus on eliminating or reducing the potential for exposure through these pathways. The calculated risk-based concentrations under groundwater usage exposure routes, as presented in Table 1-1, are below current standard analytical quantitation limits. In order to establish practical cleanup goals, MCLs or RCRA action level standards were used to establish cleanup goals for the groundwater at the site. The calculated risk-based concentrations are presented in Table 2-1 along with other values provided by ARARs (MCLs and RCRA action levels).

2.2.3 Specific Soil RAOs

Based upon the risk assessment, two soil contaminants were determined to pose significant health risks: TCE and vinyl chloride. Although CCl_4 soil contamination was not determined to pose a significant health risk (i.e., did not pose excess cancer risks greater than the 10^{-6} level), soil contamination is suspected of contributing to the CCl_4 groundwater contamination, and soil concentrations exceeded the proposed RCRA corrective action levels. Therefore, cleanup goals have been established for CCl_4, TCE, and vinyl chloride. For

CCl_4, the proposed RCRA action level (5 mg/kg) was used to set the cleanup goal. For TCE, the risk-based concentration (3 mg/kg) was more stringent than the RCRA action level (60 mg/kg), and was therefore established as the cleanup goal. For vinyl chloride, the risk-based Ecology and Environment, Inc. (E & E) concentration (0.0008 mg/kg) was the only numerical standard (i.e., no RCRA action level); however, the cleanup goal was set at the standard Contract Laboratory Program (CLP) quantitation limit for the compound (0.01 mg/kg). This level still reduces risks to within the acceptable range (10^{-4} to 10^{-6}).

Cleanup goals were also evaluated for other VOCs of potential concern in soils at the site. However, the concentrations of the remaining VOCs detected at the site were well below RCRA action levels (for compounds having established standards) and did not pose a significant health threat (i.e., greater than 10^{-6} excess cancer risk). Also, other VOCs were detected within the same areas that had significant CCl_4 or TCE concentrations. Any remedial efforts focused on addressing CCl_4, TCE, and vinyl chloride will also be effective in reducing concentrations of other VOCs. Therefore, for remediation purposes, the following preliminary soil remediation goals are recommended:

- CCl_4 - 5 mg/kg,
- TCE - 3 mg/kg, and
- Vinyl chloride - 0.01 mg/kg.

2.2.4 Specific Groundwater RAOs

MCLs, RCRA action levels, and risk-based concentrations were considered for establishing cleanup goals for site groundwater, as shown on Table 2-1. In addition, standard quantitation limits were considered to ensure that it would be technically feasible to verify cleanup following remedial action. For most compounds, MCLs are recommended for cleanup goals. Although risk-based concentrations were lower than MCLs, they were also lower than standard quantitation limits (generally 5 μg/L). Also, for all contaminants for which risk-based concentrations were calculated, the MCLs still pose risks below the 10^{-4} level for carcinogens, and still pose non-carcinogenic risks below a hazard index of 1. Since MCLs fall within the acceptable risk range of 10^{-4} to the 10^{-6}, and are technically achievable with regard to quantitation limits, they are recommended as cleanup goals.

MCLs were not selected as the cleanup goal for all compounds. For chloroform, the MCL of 100 $\mu g/L$ was promulgated for the sum of trihalomethane concentrations, not just for chloroform. The RCRA action level established specifically for chloroform (6 $\mu g/L$) is more stringent and is still within standard quantitation limits. In addition, the MCL for chloroform (100 $\mu g/L$) would allow for risks that exceed the 10^{-4} level, while the RCRA action level (6 $\mu g/L$) would reduce risks to within the 10^{-4} to 10^{-6} range. Therefore, the RCRA action level is recommended as the cleanup goal for chloroform.

Although Table 2-1 lists 14 VOCs detected in site soils and/or groundwater, site data do not necessarily justify the establishment of cleanup goals for all of the compounds. Not all of the VOCs listed on Table 2-1 were detected in site groundwater; some were only detected in soils. Some contaminants were only detected in a few groundwater samples at low concentrations, and in general were present in samples that also contained other VOCs. For remediation purposes, the following preliminary groundwater remediation goals are recommended:

- CCl_4 - 5 $\mu g/L$,
- TCE - 5 $\mu g/L$,
- 1,1-dichloroethene - 7 $\mu g/L$,
- 1,2-dichloroethene - 70 $\mu g/L$,
- Chloroform - 6 $\mu g/L$,
- Tetrachloroethene - 5 $\mu g/L$, and
- Vinyl chloride - 2 $\mu g/L$.

2.3 GENERAL RESPONSE ACTIONS

Based upon the RAOs identified in Section 2.2, and the findings of the RI, remedial efforts contemplated during this FS will focus on the two identified soil source areas and on identified groundwater contaminant plumes. The TCE source area, located at the west end of the classification yard in the vicinity of tracks 65 and 66, consists of silt/sand in which TCE has been detected from the ground surface to an approximate depth of 6 feet. The CCl_4 source area, located at the east end of the classification yard in the vicinity of track 69, consists of silt/sand in which CCl_4 has been detected at depths ranging from approximately 18 to 28 feet below ground surface (BGS). This source area is overlain and underlain by more permeable sand and gravel. and the water table is located at approximately 8 feet to 10 feet BGS.

Remedial efforts for groundwater will address contamination identified beneath the Conrail railyard and contamination that has migrated downgradient from the railyard (the County Road 1 Plume and the LaRue Street Plume). The approximate areal boundaries of the identified groundwater contamination are delineated on Figure 2-1.

Remedial alternatives contemplated during this FS, beyond the No Action Alternative, will take into consideration the interim action being conducted at the site, which was described in Section 1.2.1. In particular, alternatives will be developed and evaluated under the assumption that affected areas will be connected to the City of Elkhart municipal water supply system and that a groundwater extraction system will be installed and operated to contain the County Road 1 Plume. This system was not intended to stand alone as a final remedial action for the Conrail Site. The system would not meet the RAOs for the site, but it could serve as an integral part of a more comprehensive remedial action.

General Response Actions (GRAs) can be considered as conceptual alternatives. The GRAs discussed here address the RAOs in some manner with the exception of the No Action Alternative. The No Action Alternative was included in the alternatives for each area of concern as a baseline for comparison with other potential GRAs. The No Action Alternative is also required by SARA to be evaluated.

The GRAs presented here will be considered for the remedial action. Although GRAs are introduced individually in this subsection, they are often used in combination with other GRAs (e.g., collection is frequently followed by treatment and/or discharge). Most of the remedial action alternatives developed in Section 4 use a combination of GRAs.

2.3.1 No Action

The no action GRA serves as a baseline for comparison with other potential GRAs. If no action is implemented at the Conrail Site, substances would remain in the soil and groundwater, serving as a potential source of contamination to presently unaffected soil and groundwater. The human health and environmental risks posed by site contaminants would remain the same, and the RAOs would not be achieved. Natural biological processes would require a long period of time to degrade the organic constituents present at the site, and could possibly generate hazardous degradation byproducts. If no remedial action is implemented at the site, the migration of contaminants in the soil and groundwater would continue unabated.

2.3.2 Additional Investigation

As a result of investigations at the Conrail Site, it is suspected that additional sources of contamination, unidentified to date, are currently contributing to groundwater contamination. The presence of unidentified VOC sources can significantly impact the effectiveness of groundwater remedial actions, and could potentially lengthen the time frame required to achieve RAOs. Although a significant amount of investigation has been conducted to date, further information searches and additional investigations of site conditions (possibly soil sample collection/analysis, lead-screen auger groundwater sampling, and/or additional monitoring well installation/sampling) would provide more information regarding potential sources to aid in the design of an effective groundwater remediation system. This GRA will in no way reduce or affect the contamination at the site, but could be an integral part of comprehensive site remedial action.

2.3.3 Institutional Actions

Institutional actions are administrative methods for preventing or limiting access to affected environmental media. For soil, institutional actions include issuing deed restrictions that limit site uses and erecting barriers such as fencing and warning signs that restrict persons' direct contact with contaminated soil. For groundwater, institutional actions include installing monitoring systems, issuing deed restrictions that prevent the installation of new wells, abandoning existing wells, and providing an alternate water supply. In addition, the risk assessment identified the potential for significant health risks posed by VOC vapors rising from groundwater into residential buildings downgradient from the railyard. Air monitoring (e.g., sample collection and analysis) would determine which buildings, if any, are significantly impacted. This GRA alone would not meet the RAOs, but could be instituted along with other GRAs to reduce site workers' and area residents' potential exposure to contaminants before, during, and after remedial activities.

2.3.4 Vapor Abatement

As a result of air monitoring/sampling, it may be determined that VOC vapors are accumulating in buildings (residential or commercial) on or downgradient from the Conrail railyard. To address VOC vapors, basements and/or floors can be sealed to limit migration pathways from the underlying soil into buildings (e.g., grouting of cracks). Also, a venting system can be installed and operated to ensure that sufficient air flow reduces VOC concentrations below levels that may pose significant health risks. Abatement of VOC vapors on the railyard outside of buildings is not feasible. Although this GRA does not address soil or groundwater contamination, and alone would not meet all RAOs, it does reduce the potential for human exposure to VOC vapors.

2.3.5 Containment

Soil and groundwater can be contained to prevent direct contact by receptors or to restrict the migration of contaminants into adjacent soil and groundwater. Containment is often accomplished through the use of a physical barrier but, in itself, would not reduce the toxicity or volume of the contaminants. Typical technologies applied include vertical barriers for groundwater containment and caps for soil containment. Containment can also be attained through the use of hydraulic gradient control. Containment alone will not achieve all RAOs but could limit further groundwater contamination.

2.3.6 Removal (Soil)/Collection (Groundwater)

These GRAs provide a means by which the source of contamination and/or the affected medium is physically collected and/or removed from the site for further treatment and/or disposal/discharge. Contaminated soil is frequently removed through excavation with standard construction equipment and replaced with clean fill. Contaminated groundwater can be collected through the use of extraction wells or subsurface drains (collection trenches). This GRA alone will not meet the RAOs, but may be necessary prior to treatment, disposal, or discharge.

2.3.7 Treatment

Treatment technologies are processes that reduce the toxicity, mobility, or volume of contaminants. Typical technology types employed for treatment include physical, chemical, thermal, or biological processes. Depending on the characteristics of the wastes to be treated, a combination of processes may be necessary to properly treat the wastes. Treatment processes can be employed either on site, off site, or *in situ* and can potentially meet the RAOs.

2.3.8 Disposal (Soil)/Discharge (Groundwater)

Once material has been removed or collected, it must be properly disposed of or discharged. Because disposal/discharge alone may not meet the RAOs, this GRA is usually implemented following removal/collection and/or treatment. On-site and off-site disposal options will be considered for contaminated soils and residual solid waste material generated during remediation activities. On-site and off-site discharge options will be considered for treated or untreated groundwater and residual liquid wastes generated during remediation activities.

Specific remedial technologies have been identified for each of the GRA categories described above, with the exception of the No Action GRA. Technologies were identified that address soil and/or groundwater contamination by either:

- Providing more information on the presence and migration of contaminants;
- Limiting human exposure to contaminated media by eliminating or reducing exposure pathways;
- Controlling further migration of contaminants; or
- Eliminating or reducing the presence of contaminants.

Identified technologies are described, screened, and evaluated in Section 2.4.

2.4 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

Applicable remedial technologies were identified and screened for each GRA identified in Section 2.3. These remedial technologies were screened based upon engineering judgment, taking the following factors into account:

- Site conditions and characteristics that may affect implementability;

- Physical and chemical characteristics of contaminants that determine the effectiveness of various technologies; and

- Performance and operating reliability of various technologies.

Cost criteria were not considered in the screening of applicable remedial action technologies. Remedial action technology types can be thought of as a subcategory of GRAs. Each technology type may encompass a number of remedial action process options. Process options are defined as specific processes, systems, or actions that may be utilized to remediate or mitigate contamination. Individual process options are generally combined to form remedial action alternatives. The identification and screening of soil and groundwater remedial technologies are discussed in the following sections and are summarized in Tables 2-5 and 2-6, respectively.

2.4.1 Soil Remedial Technologies

With the exception of the No Action GRA, remedial technologies have been identified for each GRA discussed in Section 2.3 to address contaminated soil at the Conrail Site. Containment, removal, and treatment technology process options have been identified and screened specifically for the soil contamination source areas identified at the site. Table 2-5 summarizes all technology process options identified for soil.

2.4.1.1 Additional Investigation

Further site investigation could be performed to locate and delineate contaminant sources that have not been identified to date. As a result of the Phase III RI, it is suspected that other source areas in the Conrail railyard (beyond the soil sources discussed in this document) currently contribute to groundwater contamination. Identification and delineation of sources, and subsequent removal/treatment of these sources, could significantly reduce the time frame needed to achieve RAOs for groundwater. Additional investigation could include information searches, as well as field activities such as borings, soil sample collection and analysis, or lead-screen auger borings. Additional investigation was retained for further evaluation.

2.4.1.2 Institutional Actions

Land use and deed restrictions, encompassing such items as warning signs, access restrictions (i.e., fences), and legal deed restrictions, can be utilized to limit receptor exposure to contaminated media. These options do not directly affect the chemicals or affected media and provide no means of remediation, but rather serve as a barrier to minimize or eliminate direct human contact with contaminated soil that remains in place. Deed restrictions could be used to limit future development of the site property. Groundwater monitoring is another institutional control that will be an integral part of any remedial effort. Although monitoring is primarily used to track groundwater contamination, it can also be used to evaluate the effectiveness of remedial actions being implemented to address soil contamination. Although institutional actions will be initiated as part of the interim action for the site, these institutional controls may need to be expanded in scope to address long-term protection of human health and the environment. Therefore, institutional actions were retained for further evaluation.

2.4.1.3 Containment

Containment options do not directly affect the contaminated soil and provide no means for remediation, but serve as a barrier to limit further migration of contaminants within the soil. Technologies such as caps and vertical and horizontal barriers isolate contaminated soil from contact with air, surface runoff, infiltration, and/or groundwater, thereby controlling further transport of contaminants. These technologies are discussed below. Containment of contaminants in soil within the saturated zone can also be achieved through groundwater extraction, (i.e., hydraulic gradient control), which is discussed in Section 2.4.2.4 under groundwater containment.

Capping

Capping involves placing impermeable material layers on the surface of areas containing contaminated soil. These layers minimize precipitation and surface runoff from infiltrating and leaching contaminated areas. Caps prevent persons and animals from contacting contaminated soils. Caps also prevent contamination from volatilizing into the air and from being transported by windborne dust particles. Capping technologies include single-layered and multilayered caps.

Single-Layered Caps. Single-layered caps are composed of either synthetic membrane, clay, asphalt, concrete, or chemical sealants and are usually not acceptable unless the cap will be continually maintained. For example, an asphalt cap that can be inspected on a frequent basis may be acceptable. The most effective single-layered caps are composed of concrete or asphalt. Periodic application of surface treatments for asphalt and concrete caps can greatly improve their life and effectiveness. The following are examples of single-layered caps.

- **Sprayed Asphalt Membrane.** This technology involves clearing and grubbing and surface grading of the area, and spray application of a ¼-inch- to ½-inch-thick layer of asphalt to reduce infiltration and limit air mobilization of particulates from the soil surface. This technology requires little materials handling and a small labor force, and is easy to implement. The resulting membrane, however, is not very durable. It is photosensitive, has poor weathering resistance, becomes brittle with age, and is susceptible to severe progressive cracking. In addition, spilled organic substances such as solvents or diesel fuel can impact asphalt. The fragile nature of this type of cap limits its effectiveness in preventing precipitation from passing through the cap into underlying soils.

- **Portland Cement Concrete.** This technology involves clearing and grubbing and surface grading of the area, and placement of a 6-inch-thick base course and a 4-inch to 6-inch-thick concrete slab (with minimum steel mesh) to minimize infiltration and eliminate emissions of particulates from the surface soil. The technology is durable and resistant to chemical and mechanical damage. However, concrete is susceptible to cracking from settlement, shrinkage, and frost heave. Installation requires the placement of forms and steel and the construction of expansion joints. Proper design and installation generally results in relatively low maintenance costs.

- **Bituminous Concrete.** This technology involves clearing and grubbing and surface grading, and placement of a 6-inch-thick base course and a 2-inch to 4-inch-thick slab of asphalt pavement to minimize filtration and eliminate emissions of particulates from the soil surface. This technology has proven effectiveness. However, like more rigid materials, asphalt is susceptible to cracking from settlement and shrinkage. Asphalt is photosensitive and tends to weather more rapidly than concrete. This weathering generally contributes to operation and maintenance expenses that are greater than for concrete.

Multilayered Caps. Multilayered caps are most common and are required for RCRA land disposal facilities by regulations 40 CFR 264, Subparts K through N. These caps can be composed of natural soils, mixed soils, a synthetic liner, or any combination of these materials. Standard design practices specify permeabilities of less than or equal to 10^{-7} cm/sec for the soil liner. The following are examples of multilayered caps.

- **Loam over Clay.** This technology involves clearing and grubbing, grading, and the placement and compaction of 24 inches of clay to minimize infiltration and eliminate particulate emissions from the soil surface. The clay is covered with 12 inches of loam (topsoil) to control moisture, protect the integrity of the clay layer, and allow revegetation. This technology is effective; it has longevity and durability, assuming proper design, installation, and maintenance. It is effective because it is less susceptible to cracking from settlement and frost heave, and tends to be self-repairing. Long-term maintenance would be required to prevent growth of deep-rooting trees and shrubs that could penetrate the clay seal.

- **Loam over Sand over Synthetic Membrane over Sand.** This technology involves clearing and grubbing, surface grading, and covering site soils with a 12-inch-thick blanket of sand overlain with an impermeable synthetic membrane that is covered by a 12-inch-thick sand drainage layer. This sequence of materials is covered by 8 inches of loam (topsoil) to allow revegetation. This technology is effective; however, the installation is time-consuming and difficult. Six separate operations are required to complete the construction, and the seams in the membrane require careful installation and sealing. Flexibility of the membrane makes this technology relatively less susceptible to cracking from influences such as settlement and frost heave; however, the self-repairing capacity of clay is not provided with this type of cap.

- **Loam over Sand over Synthetic Membrane over Clay (RCRA Cap).** This technology involves clearing and grubbing, grading, and covering site soils with 24 inches of compacted clay and an impermeable synthetic membrane that is in turn covered by 24 inches of compacted sand. The compacted clay and synthetic membrane act as barriers to the infiltration of water, while the top sand layer provides a drainage-way for percolating water. Overlying this sequence of materials is 12 inches of loam (topsoil) to allow revegetation. This sequence of materials meets RCRA requirements for capping at a new facility. This technology takes advantage of the self-repairing properties of clay, along with the impermeable nature of a synthetic membrane. Six operations are required to complete the construction of this cap, and seams in the membrane require careful installation and sealing.

Environmental, public health, and institutional impacts of the various capping technologies would all be similar. During construction, short-term impacts would include noise, dust, and increased truck traffic through neighborhoods. Also, portions of railroad track would have to be temporarily removed and then replaced in order to construct an effective cap. This would hinder current rail operations since the site is an active railyard. Further migration of VOCs from shallow, unsaturated soil source areas (e.g., the TCE source area) to groundwater would be limited because of the reduced infiltration and leaching of contaminants from the vadose zone. However, soil contamination in the saturated zone (e.g., the CCl_4 source area) would not be significantly contained through capping, since infiltration/percolation is not the primary migration pathway for those areas. In areas that are capped, soil contaminants would remain in place as a potential source of future groundwater contamination and public exposure. In addition, settlement from train loads and shifting tracks may compromise the integrity of a cap. For these reasons, capping technologies were not retained for further consideration at the Conrail Site.

Vertical Barriers

Impermeable walls such as slurry walls, grout curtains, and sheet pilings may be used as vertical barriers. These barriers may be used to control lateral migration of contaminated groundwater or to divert clean groundwater from coming into contact with contaminated soil areas. The three types of vertical barriers are discussed below.

- **Slurry Walls.** Slurry walls are impervious barriers constructed through the subsurface soils. Construction of these walls creates a barrier to the flow of groundwater. This barrier can be used both to redirect the groundwater flow upgradient of the site and to contain groundwater leaving the site on the downgradient side. These slurry walls are constructed with either a soil-bentonite or a cement-bentonite slurry. Most commonly, a vertical trench of limited width is excavated with a backhoe or other appropriate equipment. In a soil-bentonite slurry wall, the trench sides are supported by a hydrated bentonite slurry during excavation and the trench is subsequently filled with a mixture of select soil and bentonite slurry, thus creating a continuous wall. In a cement-bentonite slurry wall, a properly designed cement-bentonite slurry is introduced into the trench during excavation. This slurry provides support to the trench sides during excavation and is allowed to harden to form the wall. Slurry walls involve the excavation of a trench while the trench is continuously backfilled with a slurry of bentonite clay and water and the original soil. The completed wall can be impervious or negligibly permeable. The slurry wall must connect to an impermeable layer, bedrock, or clay to successfully contain the groundwater.

- **Grout Curtains.** A grout curtain is an impermeable barrier that is created by the pressure injection of either suspension or chemical grouts into a rock or soil mass. Groundwater control is achieved by the gelling or setting of the injected grouts in rock or soil voids, reducing the permeability and increasing the mechanical strength of the medium. Cement, microfine cement, clays, bentonite, alkali silicates, and some organic polymers have been used as grouts. The most cost-effective use of grout curtains is in sealing porous and fractured rock. Because of costs, grouted barriers are seldom used for containing groundwater flow in unconsolidated materials around hazardous sites. Slurry walls in soil or loose overburden situations are significantly less costly than grout curtains.

- **Sheet Piling**. Sheet piling cut-off walls may serve as a groundwater barrier to redirect groundwater flow. Such cut-off walls may be used to redirect groundwater to eliminate contact with contaminated soil and/or to prevent contaminated groundwater from migrating off site. Sheet piles can be made of wood, precast concrete, or steel. Steel sheet piling is most effective in terms of groundwater cut-off effectiveness and cost compared to other materials that can be used for sheet piles. The installation of a steel sheet piling cut-off wall requires that the pilings be assembled at their edge interlocks before being driven into the ground. The piles are then driven a few feet at a time over the entire length of the wall, using either a pneumatic or steam pile driver, until the appropriate depth is obtained. Initially, steel sheet piling cut-off walls are quite permeable at the edge interlocks, which must be loose to facilitate the driving process. Eventually, fine soil particles adhere within the seams and the wall becomes impermeable to groundwater flow. In very coarse, sandy soils the wall may never seal, unless the piling seams are first grouted, which adds to the overall cost. Corrosion of the steel from chemical exposure to soil and groundwater contaminants can be reduced by the use of galvanized steel, but at an increased cost. In general, steel sheet piling cut-off walls tend to be more expensive than slurry walls.

The overall implementability and effectiveness of vertical barriers would be questionable. During construction, short-term impacts would include noise and removal and replacement of portions of track. As in the case of cap installation, removing track would hinder current rail operations. Long-term contaminant containment may not be achieved because of the nature of the aquifer. The water table is shallow and the overburden is relatively permeable. Furthermore, in order to be effective, such barriers would need to be connected ("keyed" into) a confining geologic layer. The only such layer beneath the site is bedrock, which occurs at a depth of 140 to 150 feet BGS. This depth is well beyond the practical limits of physical barrier placement. In addition, hydraulic gradients resulting from downward leakage and rainfall infiltration are not greatly altered by vertical barriers; in fact, the downward movement of contamination may be increased because of the reduction of the horizontal component of groundwater movement by the slurry wall. Since this remedial technique does not address the possibility of downward migration of contaminants, capping would need to be implemented as well. For these reasons, the vertical barrier technology was not retained for further consideration.

Horizontal Barriers

Horizontal barriers are constructed by injecting grouting materials such as cements, microfine cement, clays, bentonite, alkali silicates, silicates, and organic polymers at predetermined spacings at the desired depths of the barrier. The spacings of the grout injections are determined by a geotechnical investigation that considers the type and permeability of the soil and the type of grout. The grout forms an impermeable barrier by gelling or setting in rock cracks or soil voids.

Short-term impacts associated with construction of horizontal barriers are similar to those described for vertical barriers. As for long-term effectiveness, the reliability of horizontal barriers is questionable; only a few horizontal barriers have actually been constructed. As with vertical barriers, the nature of the aquifer and the depth of the contamination would reduce the effectiveness and implementability of horizontal barriers. For these reasons, the horizontal barrier technology was not retained for further consideration.

2.4.1.4 Removal

The removal of contaminated soils could be accomplished by excavating on-site soils. Excavation is an effective method for physically removing contaminated surface and subsurface soils from a site. Excavation involves the use of standard construction equipment that is adapted to minimize secondary migration. Excavated material must subsequently be treated and/or disposed of as described in the following subsections. Excavation pits may be backfilled with clean fill or treated soil if the soil meets cleanup standards.

There are many short-term impacts and considerations. Dust-suppression systems would be needed to prevent airborne contamination. Local truck traffic would increase in neighboring areas if off-site treatment/disposal methods are chosen for the contaminated soil. Excavation of the identified source areas at the site would require the temporary removal and subsequent replacement of portions of track, resulting in interruptions to rail use. Removal of the CCl_4 source in the track 69 area, located approximately 10 to 20 feet below the water table, would require special construction procedures. Excavation of saturated soils could be accomplished using wet excavation techniques (e.g., dredging) or by dewatering and then excavating the soils. In order to dewater the contaminated zone to allow excavation, a large volume of water would have to be extracted, treated, and discharged continuously during excavation. Because of the sandy nature of the site soil, excavation at depths of up to 30 feet would require stepping or sloping of the pit or the construction of structural supports (e.g., sheet piling) to keep pits open and ensure worker safety. Sloping or stepping would require excavating a larger area than the actual contaminated soil area and a large staging area for temporary stockpiling of excavated soil. Despite these considerations, excavation is considered a viable option for the removal of contaminated soil at the site.

2.4.1.5 Soil Treatment

Potential soil treatment technologies can be employed either on site or off site using one of the following four general approaches:

- On-site treatment of excavated soil using mobile treatment systems;
- On-site construction and operation of treatment systems for excavated soil;
- *In situ* treatment of soil; and
- Transportation of excavated contaminated soil to an off-site treatment facility.

The treatment technology process options that have been identified and screened for the Conrail Site fall into four categories:

- Physical/chemical treatment processes;
- Thermal treatment processes;

- Biological treatment processes; and

- *In situ* treatment processes.

Processes which fall under the first three categories require excavation of soil prior to treatment. Treatment for these options would take place above-ground on-site or off-site. However, *in situ* processes (which may be physical/chemical, thermal, or biological in nature) may be applied to soils in place, and therefore do not require excavation of soils. Each process option is discussed below.

Physical/Chemical Treatment Processes

Physical treatment processes can be used to separate the waste stream by either applying physical force or changing the physical form of the waste, whereas chemical treatment processes alter the chemical structure of the constituents to produce a waste residue that is less hazardous than the original waste. Further, the altered constituents may be easier to remove from the waste stream. Physical and chemical processes can also be used to immobilize contaminants within the waste material. Physical and chemical treatment processes are utilized to treat inorganic as well as organic hazardous wastes, particularly those that are either nonbiodegradable or resistant to biodegradation. Possible treatment technologies that were initially identified include stabilization/solidification, soil washing, dechlorination, chemical reduction-oxidation, and chemical extraction. These technologies are discussed below. Additional physical/chemical treatment processes are discussed later in this section under the heading *In Situ* Treatment Processes.

- **Solidification/Stabilization**. Solidification/stabilization treatment systems, sometimes referred to as fixation systems, are employed to improve the handling and physical characteristics of the waste, reduce the surface area across which transfer or loss of contaminants can occur, and/or reduce the solubility of hazardous constituents in the wastes. Solidification involves techniques that seal the wastes into a relatively impermeable stable block. Stabilization involves techniques that would either neutralize or detoxify the wastes, so that the contaminants are maintained in the least less soluble or toxic form. Solidification/stabilization methods used for chemical soil consolidation can immobilize contaminants. Most of the techniques involve a thorough mixing of the solidifying agent and the waste. Solidification of wastes produces a monolithic block with high structural integrity. Organic contaminants do not necessarily interact chemically with the solidification reagents but are mechanically locked within the solidified matrix. Stabilization methods usually involve the addition of materials that limit the solubility or mobility of waste constituents even though the physical handling characteristics of the waste may not be improved. Remedial actions involving combinations of solidification and stabilization techniques are often used. Solidification has been most successfully applied to inorganic wastes and is considered by EPA to be appropriate for large volumes of waste material containing toxic heavy metals. Solidification/stabilization is not well demonstrated, however, for the remediation of soil containing VOCs. Volatile organics are typically not immobilized (creating the potential for migration as vapors) and may be driven off by heat-of-reaction processes (i.e., carrying or settling), although certain proprietary processes claim to bind lighter organic compounds. Furthermore, the solidified soil would still have to be managed as a hazardous waste under RCRA and would be subject to land-disposal requirements. For these reasons, this technology was not retained for further consideration.

- **Soil Washing**. The soil washing process extracts contaminants from sludge or soil matrices using a liquid washing solution. This process can be used on excavated soils that are fed by a washing unit. This unit operation separates the fine solids from the coarser soils, concentrating the fines, which results in volume reduction. This volume reduction approach is based on the observation that the vast majority of soil contaminants are adsorbed to the finer fractions of the soil. The washing solution may be composed of water, organic solvents, water/chelating agents, water/surfactants, acids, or bases, depending on the contaminant to be removed. For the VOC contaminants identified at the Conrail Site, washing solutions of alkaline agents, surfactants, and biodegradable polysaccharides are appropriate. After soil treatment, the washing solution is treated for removal of fines and contaminants through a conventional wastewater treatment system. The treated solution is then recycled to the beginning of the process. The washed soil may be backfilled. The treatment waste stream (i.e., concentrated VOCs) may require either incineration or additional treatment prior to disposal. This process has limited effectiveness under conditions such as unfavorable contaminant separation coefficients, complex mixtures of waste (i.e., metals with organics), high humic content in soil, soil solvent reactions, fine soils (i.e., silt and clays), and unfavorable washing solution characteristics (i.e., poor recovery, treatability, or toxicity). Other limitations include the requirement for treatment of exhaust air because of VOCs stripped in the washing process and the need for soil excavation. This process does not appear to be efficient because the contaminants are transferred to multiple medias, each needing additional treatment, and the multiple steps required. For these reasons, soil washing was not retained for further consideration.

- **Dechlorination**. Dechlorination is a treatment process that uses a chemical reaction to replace the chlorine atoms in chlorinated aromatic molecules (such as PCP, dioxins, and furans) with an ether or hydroxyl group. By stripping the chlorine atoms, the toxicity of the chlorinated aromatic compounds is reduced or eliminated. An evaluation of the end products would be required to determine whether further treatment is required. Potassium polyethylene glycolate (KPEG) dechlorination is an innovative process used to dehalogenate certain classes of chlorinated organics in contaminated organic liquids, sludges, and soils. KPEG is used on waste oils containing dioxins and diesel fuel containing PCBs, dioxins, and chlorobenzenes, to convert them into lower-toxicity, water-soluble materials. Since the contaminants of concern at the Conrail Site are not aromatic, this technology was not retained for further consideration.

- **Chemical Reduction-Oxidation**. The chemical reduction-oxidation (redox) process is employed to destroy hazardous components or convert the hazardous components of the waste stream to less hazardous forms. Redox processes are based on reduction-oxidation reactions between the waste components and added reactants in which the oxidation state of one reactant is raised while that of another is lowered. A significant use of chemical redox is the reduction of hexavalent chromium (Cr^{+6}) to trivalent chromium (Cr^{+3}), which is less toxic and more susceptible to chemical precipitation. Redox has also been used to treat mercury-, silver-, and lead-contaminated wastes. Common reducing agents include alkali metals (sodium, potassium), sulfur dioxide, sulfite salts, ferrous sulfate, iron, aluminum, zinc, and sodium borohydrides. Chemical oxidation is used primarily for treatment of cyanide and dilute waste streams containing oxidizable organics. Among the organics for which oxidative treatment has been reported are aldehyde, mercaptans, phenols, benzidine, unsaturated acids, and certain pesticides. Common commercially available oxidants include potassium permanganate, hydrogen peroxide, hypochlorite, and chlorine gas. The chemical redox treatment process consists of initial pH adjustment, addition of redox reagents, mixing, and treatment to remove or precipitate the reduced or oxidized products. Chemical redox has limited application to sludges because of difficulties in achieving intimate contact between the reagent and the hazardous constituent. Sludges must be slurried prior to treatment to achieve a suspended solids content of 3% or less. Applying chemical redox processes to soil matrices would not be effective and, therefore, it was not retained for further consideration.

- **Chemical Extraction**. Chemical extraction is a physical treatment technology in which contaminants are separated from the soil particles, becoming dissolved or dispersed in a liquid solvent. The contaminants are subsequently removed from the liquid waste stream, generally using conventional wastewater treatment systems, and the solvent is recycled, if possible. Solvents with greatest potential for soil remediation generally include water; water augmented with an acidic or chelating agent to remove inorganics and heavy metals; and water augmented with a basic or surfactant agent to remove organics. This technology is as limited in effectiveness and implementability at the Conrail Site as was the soil washing technology. Effectiveness may be reduced by unfavorable contaminant separation coefficients, complex mixtures of waste (i.e., metals with organics), high humic content in soil, solvent reactions, and fine soils. Other limitations include the treatment of the liquid waste stream and possibly needed treatment for exhaust air resulting from VOCs stripped in extraction process. For these reasons, chemical extraction was not retained for further consideration.

Thermal Oxidation Processes

Thermal oxidation uses high-temperature oxidation under controlled conditions to degrade a substance into products that generally include carbon dioxide, water vapor, ash, and hydrochloric acid (if chlorinated solvents are present). Thermal destruction methods can be used to destroy organic contaminants in liquid, gaseous, and solid waste streams. Thermal destruction is a proven technology that can effectively and rapidly treat all organic compounds at high capital and energy costs.

Thermal oxidation is not an effective remedial technique for metals. Volatile metals compounds (e.g., arsenic) in the soil may present particulate emissions problems. These metal particulates are difficult to remove from the air using conventional air pollution control equipment because of the small particle size. Nonvolatile metals (e.g, chromium, copper) tend to remain and concentrate in the incinerator ash. Depending upon its metal(s) concentration, the incinerator ash may require disposal in a secure facility and/or further treatment.

Several types of incinerators are technically feasible and have been used to treat hazardous waste. Options available include on-site incineration and off-site incineration. The relatively low anticipated volume of contaminated soil that would be excavated at the Conrail Site does not warrant construction of an on-site incinerator. Transportation of excavated soil to an off-site incinerator or an on-site mobile incinerator would provide an effective means of destroying the organic contaminants. Incineration and thermal destruction technologies applicable to the Conrail Site are discussed below.

- **Rotary Kiln Incinerators.** Rotary kiln incinerators consist of a long, rotating kiln, which is slightly inclined. Wastes and auxiliary fuel are fed into the elevated end of the kiln. The waste material is combusted as it passes through the kiln. The kiln is slowly rotated to enhance the mixing of the waste with combustion air, thereby facilitating the combustion process. Residence times within the kiln can vary from several minutes to an hour or more to ensure that organic contaminants have been destroyed. Ash is removed at the lower end of the kiln. Flue gases are passed through an afterburner for further oxidation and are subsequently treated using conventional air pollution control-equipment to limit particulate and acid gas emissions. Rotary kiln incineration is applicable to liquid, solid, and slurried hazardous wastes, and is the most commonly used incineration method for contaminated soils. Both stationary and mobile rotary kiln incinerators are commercially available.

- **Infrared Incineration.** Infrared incineration uses infrared energy (generated by silicon carbide resistance heating elements) as an auxiliary heat supply for destruction of combustible materials. Materials to be treated pass through the primary combustion chamber on a woven wire conveyor belt and are exposed to infrared radiation, where solids are pyrolyzed. Oxygen is introduced to help fully combust off-gases. Ash residue is dropped off the belt into a hopper where it is collected. Exhaust gases pass through a secondary chamber to ensure complete combustion of remaining organics. Exhaust gases are then passed through pollution-control equipment for particulate removal, acid gas control, and gas cooling. Low particulate and gaseous emissions are achieved by this process, which is used primarily to treat contaminated solids, soils, and sludges. Infrared incineration was retained for further evaluation.

- **Fluidized-Bed Incinerators.** Fluidized-bed incinerators use a bed of sand or other granular, inert material in a refractory-lined vessel to improve the heat transfer to the waste stream being incinerated. Air is blown upward through this bed to suspend the granular material, causing it to move and mix like a fluid. Waste is fed into the reactor by use of multiple injection ports and then makes contact with the heated bed particles. The high mixing energies aid in the combustion process, resulting in lower operating temperatures than other incinerators. Fluidized-bed incinerators are used to incinerate organic liquids, sludges, and solids of limited particle size (e.g., less than 1 inch). The waste material must have a low ash, low sodium, and low heavy metal content. Mobile fluidized-bed units are commercially available. Frequent cleaning and maintenance is required. The circulating bed combuster is an off-shoot of this technology. Fluidized-bed incineration was retained for further evaluation.

- **Pyrolysis.** Pyrolysis is a high-temperature thermal treatment technology involving the destruction of organic material in the absence of oxygen. Two combustion chambers are used in the process. In the primary chamber the organic gas fraction is separated from the solid fraction by heating the waste at temperatures ranging from 1,000° F to 4,000° F. The temperatures in this chamber are controlled by the addition of auxiliary fuel. There are two methods of heating the waste in the primary chamber. The first is by direct heating with hot combustion gases from a burner or incinerator, and the second is by indirect heating using an external burner or an electric resistance heating element. The second chamber is like an afterburner, in which the organic gas fraction is burned, destroying hazardous compounds. This technology is used to treat a wide variety of materials including viscous liquids, sludges, solids, metals, and high ash materials. Performance data are limited, and, consequently, pyrolysis was not retained for further consideration.

- **Thermal Desorption.** Thermal desorption is used to transfer volatile and semivolatile organic compounds from a solid matrix into a gas stream, typically using air, heat, and mechanical agitation. The organic compounds transferred into the gas stream are then subjected to further treatment (e.g, carbon adsorption or high-temperature incineration). Thermal desorption can be accomplished through the use of a mobile treatment unit that could be readily transported to the site. Thermal desorption was retained for further evaluation.

Biological Treatment Processes

Biological treatment processes use indigenous or selectively cultured bacteria, yeast, or fungi to decompose hazardous organic compounds. Biological treatment processes are sensitive to temperature, pH, oxygen concentration, moisture content, availability of nutrients, and concentrations of inhibitory substances (e.g., metals). Although biological treatment is effective in many applications, the contaminants of concern at the Conrail Site are not readily degradable and may yield toxic degradation byproducts (e.g., vinyl chloride). Therefore, the identified biological process options that are discussed below were not retained for further consideration.

- **Slurry Phase.** Slurry phase involves the treatment of contaminated soil or sludge in a large, mobile, aerated bioreactor. Excavated soil is mixed with water and nutrients in the bioreactor to allow for better mass transfer of the nutrients, contaminants, and oxygen to the microorganisms. The first step in the treatment process is to create the aqueous slurry. During this step, stones and rubble are physically separated from the waste, and the waste is mixed with water, if necessary, to obtain the appropriate slurry density. The water may be contaminated groundwater, surface water, or another source of water. A typical soil slurry contains about 50% solids by weight; a slurried sludge may contain fewer solids. The actual percent solids is determined in the laboratory based on the concentration of contaminants, the rate of biodegradation, and the physical nature of the waste. The slurry is mechanically agitated in a reactor vessel to keep the solids suspended and maintain the appropriate environmental conditions. Inorganic and organic nutrients, oxygen, and acid or alkali for pH control may be added to maintain optimum conditions. Microorganisms may be added initially to seed the bioreactor or continuously to maintain the correct concentration of biomass. The residence time in the bioreactor varies with the soil or sludge matrix and physical/chemical nature of the contaminant, including concentration and the biodegradability of the contaminants. Once biodegradation of the contaminants is completed, the treated slurry is dewatered. The residual water may require further treatment prior to disposal. Depending on the nature and concentration of the contaminants, and the location of the site, any emissions may be released to the atmosphere, or treated to prevent emission. Fugitive emissions of volatile organic compounds, for instance, can be controlled by modifying the slurry-phase bioreactor so that it is completely enclosed.

- **Solid-Phase Treatment.** Solid-phase soil bioremediation is a process that treats soils in an abovegrade system using conventional soil management practices to enhance the microbial degradation of contaminants. The system can be designed to contain and treat soil leachate and volatile organic compounds. A system used by Ecova consists of a treatment bed which is lined with an 80-millimeter high-density liner with heat-welded seams. Clean sand is placed on top of the liner to provide protection for the liner and proper drainage for contaminated water as it leaches from contaminated soils placed on the treatment bed. Lateral perforated drainage pipe is placed on top of the synthetic liner in the sand bed to collect soil leachate. If VOCs must be contained, the lined soil treatment bed is completely covered by a modified plastic film greenhouse with a vapor-phase carbon adsorption filter to treat exhaust vapors. An overhead spray irrigation system contained within the greenhouse provides for moisture control and a means of distributing nutrients and microbial inocula to the soil treatment bed. Contaminated leachate that drains from the soil is transported by the drain pipes, collected in a gravity-flow lined sump, and then pumped to an on-site bioreactor for treatment. Treated leachate can then be used as a source of microbial inocula and reapplied to the soil treatment bed through an overhead irrigation system, after adjusting for nutrients and other environmental parameters.

- **Land Farming.** Land farming is an aboveground biological treatment process option for soils. In land farming, excavated contaminated soils are inoculated and spread in thin, 1- to 2-foot layers and turned periodically to allow adequate oxygen transfer. It is important to maintain optimum nutrient and moisture conditions to promote microbial growth. Land farming requires a large staging area that provides an adequate containment and collection system for contaminated precipitation, runoff, and leachate. Accordingly, land farming may be interpreted as a form of land disposal under RCRA. Thus, the RCRA land disposal restrictions may prohibit the applicability of this process option.

***In situ* Treatment Processes**

In situ treatment processes are utilized to treat/remove contamination in/from soil that cannot be readily excavated. Because of the active use of the Conrail rail yard and the extensive network of track, *in situ* treatment processes for soils appear to be the most promising for implementation at the site. Applicable *in situ* processes that have been identified and screened are discussed below.

- **Soil Vapor Extraction** is a process for removing volatile organic compounds from permeable, unsaturated soils. A vacuum extraction system consists of a network of extraction wells connected to a vacuum extraction unit through a surface collection manifold. The vacuum induces a flow of air into the extraction wells in order to draw vapors from the soil, bringing about the release of volatile compounds. Depending on the nature and extent of contamination, the extracted gas can either be vented to the atmosphere or treated (e.g., through carbon adsorption or incineration) to remove VOCs prior to emission to the atmosphere. This process can be augmented by the injection of air around the boundaries of contamination to increase the flow of air through the soil or by capping the surface to eliminate short-circuiting of air from the surface to the extraction system. Vapor extraction was retained for further evaluation.

- **Air Sparging** involves the injection of air into saturated soils to volatilize VOCs and carry them upward into the overlying unsaturated zone. Ambient air from the surface would be compressed and pumped through a series of injection wells into the area of contamination. The resulting air and vapors rising through the soil would need to be collected from the overlying unsaturated zone (via vapor extraction) or from the ground surface and vented to the atmosphere or treated (e.g., through carbon adsorption or incineration) to remove VOCs prior to emission to the atmosphere. This process can also be enhanced through the injection of steam to increase volatilization of organic compounds. However, because the contaminants of concern at the site are highly volatile, steam enhancement should not be necessary. Air sparging was retained for further evaluation.

- **Soil Flushing** is a process for washing organic and inorganic contaminants from soils. There is relatively little field-scale data on the effectiveness of this process in reducing VOC concentrations in soil. A liquid wash solution is injected into contaminated soil upgradient and then extracted downgradient to flush contaminants from the soil. During this flushing, sorbed contaminants are mobilized into solution through solubility, formation of an emulsion, or chemical reaction with the flushing solution. Soil flushing can be enhanced with additives to increase the efficiency of contaminant removal from soil. Spent wash solution requires treatment and/or disposal. This process option is only feasible if soils are relatively homogeneous and fairly coarse-grained. Otherwise, sufficient flow may not be obtained or channeling could occur, in which wash solution is diverted through a few pathways that offer little resistance, while the majority of the contaminated soil does not come into contact with the wash solution. Soils at the Conrail Site are fairly coarse-grained and somewhat homogeneous in certain areas, and therefore may be amendable to soil flushing. Soil flushing was retained for further evaluation.

- ***In situ* Vitrification** is a process whereby contaminated soils and wastes are converted in place into a glassy, solid matrix by means of very high temperatures (1,600° F to 2,000° F). The process is carried out by inserting electrodes into the contaminated soil to the desired treatment depth and passing high-power electric current through the soil. The soil becomes molten and then afterwards gradually solidifies in place. Non-volatile compounds are trapped in the vitrified mass and organic compounds are destroyed by pyrolysis. The pyrolized byproducts and VOCs may escape from the soil surface, in which case they must be collected and treated. Vitrification is primarily intended for use with soils contaminated with less volatile compounds. The high energy requirements, the need for vapor recovery of VOCs at the surface, the depth of contamination below the water table, and the relatively shallow depth of the water table make this process option infeasible for the Conrail Site. Vitrification was not retained for further evaluation.

- ***In situ* Bioremediation** uses indigenous or introduced aerobic or anaerobic microorganisms to break down organic compounds in soil. *In situ* bioremediation relies on creating favorable aerobic conditions to improve aerobic microbial processes. This method involves optimizing environmental conditions by providing an oxygen source and nutrients, which are delivered to the subsurface through an injection well or infiltration system to enhance microbial activity. Indigenous microorganisms can generally be relied upon to degrade a wide range of compounds, given proper nutrients and sufficient oxygen. Specially adapted or genetically manipulated microorganisms are also available and may be added to the soil/groundwater zone. Although *in situ* bioremediation is effective in many applications, the contaminants of concern at the Conrail Site, i.e., chlorinated solvents, are not readily degradable and may yield toxic degradation byproducts (e.g., vinyl chloride). Therefore, *in situ* bioremediation was not retained for further consideration.

2.4.1.6 Soil Disposal

Off-site Disposal

Wastes generated during the site remediation, which may include either treated or untreated excavated soil or residual process wastes, could be transported off site to a commercial/RCRA disposal facility, as appropriate. Any such disposal must comply with land disposal restrictions and any other ARARs. Off-site disposal was retained for further evaluation.

On-site Disposal

On-site disposal of contaminated soils and sludges generated by excavation of contaminated material or by an on-site treatment or pretreatment process requires the construction of a secure landfill that would meet RCRA and state requirements. Several criteria are associated with the construction of a RCRA hazardous waste landfill, including the following:

- The landfill should be designed so that the local groundwater table will not be in contact with the facility;
- The landfill should be constructed of, or lined with, natural or synthetic material of low permeability to inhibit leachate migration;
- An impermeable cover is required to minimize infiltration and leachate production;
- A leachate and runoff collection system must be provided; and
- Periodic monitoring of surface water, groundwater, and soils adjacent to the facility must be conducted to determine the integrity of the liner and leachate collection system.

At the Conrail Site construction of a landfill meeting these requirements would not be feasible because of the high water table and the present use of the site as an active railyard. Therefore, on-site disposal was not retained for further consideration.

2.4.2 Groundwater Remedial Technologies

Groundwater remedial technologies can be applied to contain, divert, collect, and/or treat the groundwater beneath the Conrail Site and the adjacent study area. Technologies can also be implemented to reduce exposure to VOC vapors resulting from contaminated groundwater. It is anticipated that these technologies will prevent further contaminant migration, restrict significant exposure pathways, and remediate identified contaminant plumes. No technologies were identified for the No Action GRA. All identified groundwater technology process options are listed in Table 2-6.

2.4.2.1 Additional Investigation

Further site investigation could be performed to locate and delineate contaminant sources that have not been identified to date. As a result of the Phase III RI, it is suspected that other source areas in the Conrail railyard (beyond the soil sources discussed in this document) currently contribute to groundwater contamination. Identification and delineation of sources, and subsequent removal/treatment of these sources, could significantly reduce the time frame needed to achieve RAOs for groundwater. Additional investigation could include information searches and such activities as lead-screen auger borings, additional monitoring well installation, and groundwater sample collection and analysis. Additional investigation was retained for further evaluation.

2.4.2.2 Institutional Actions

Land use and deed restrictions, encompassing such items as warning signs, access restrictions (i.e., fences), and legal deed restrictions, can be utilized to limit human exposure to contaminated media. An alternate water supply would also limit exposure to contaminated groundwater, and is currently being addressed for some site area residents under the interim action for the site. These options do not directly affect the on-site chemicals or affected media and provide no means of remediation, but rather serve to limit exposure pathways to minimize or eliminate direct human contact with affected groundwater. Deed restrictions could be used to prohibit future installation of groundwater wells in contaminated aquifers. Fencing and warning signs could be used to limit access to groundwater treatment operations. Groundwater monitoring is another institutional control that will be an integral part of any remedial effort and would be used to evaluate the effectiveness of any remedial actions. In addition, systematic monitoring of air in buildings/basements above the contaminant plumes would be needed to determine whether significant VOC concentrations are present, and if so, whether remedial action to address those vapors is necessary. Although some of these institutional actions are currently included under the scope of the interim action, they may need to be expanded to meet the RAOs (e.g., through installation/monitoring of additional wells or provision of an alternate water supply for additional residents). Air monitoring was not addressed at all under the interim action. For these reasons, institutional actions will be retained for further evaluation.

2.4.2.3 Vapor Abatement

In the event that significant VOC vapor accumulation is detected in buildings within the Conrail Site study area, vapor abatement actions will be necessary. Abatement actions could consist of sealing cracks or openings present in building basements or floors, thereby eliminating migration pathways for VOCs from underlying soils into the buildings. Also, abatement actions could include the installation and operation of an air venting system in affected buildings, which would reduce the accumulation of VOCs so that concentrations do not pose significant risks to building occupants. Vapor abatement technologies will be retained for further evaluation.

2.4.2.4 Groundwater Containment

Groundwater containment systems are used to limit the migration of contaminant plumes. Containment can be achieved by physically containing the plume or by restricting clean groundwater from contacting the contaminant plume through the use of physical barriers or through hydraulic gradient control. Physical containment technologies are discussed below. Hydraulic gradient control can be achieved through groundwater extraction which is discussed below in Subsection 2.4.2.5. Containment can be applied to the entire contaminated portion of an aquifer or to source areas with the most significant contamination.

Cap

Caps were discussed in Section 2.4.1.3 for soils. Caps would limit the infiltration of precipitation through unsaturated soils, thereby reducing the migration of contaminants from soil to the groundwater. Caps would not be effective for limiting contaminant migration to groundwater from saturated soils (e.g., the CCl_4 source area), and the long-term integrity of a cap would be questionable because of the continued use of railyard. Therefore, caps were not retained for further evaluation for the Conrail Site.

Physical Barriers

Vertical and horizontal physical barriers may be used to prevent contaminated water from migrating off site and/or to divert clean water from contacting contaminated subsurface areas. These containment technologies are discussed under soil remedial technologies (Section 2.4.1.3) even though they are better described as groundwater applications. For the same reasons that vertical and horizontal barriers were screened out for soils, physical barriers were not retained for further consideration for use as groundwater containment.

2.4.2.5 Groundwater Collection

Groundwater collection systems are used primarily to remove contaminated groundwater from an aquifer for treatment. Groundwater collection can also be used to control or contain the migration of contaminant plumes. Collected groundwater may require treatment and must ultimately be discharged. Collection technologies include extraction wells or subsurface drains and are discussed below.

Extraction Wells

Collection can be achieved by pumping groundwater from extraction wells. Pump selection for the recovery wells would depend on the anticipated lift requirements and volume of groundwater to be extracted. To ensure that the system can effectively control the hydraulic gradient of the contaminant plume, the extraction wells must be strategically placed within the contaminated aquifer, and a sufficient pumping rate must be determined. Proper operation and maintenance of the extraction system must be provided throughout the course of groundwater recovery. Extracted groundwater must be properly treated and either properly disposed of or reinjected. Groundwater extraction is currently included under the interim action to achieve containment of groundwater contamination, but also serves to collect groundwater for treatment. However, the collection of groundwater may need to be expanded to achieve long-term remedial action objectives (e.g., the interim action does not address the LaRue Street plume). The collection of groundwater through extraction wells was retained for further evaluation.

Subsurface Drains

Subsurface drains include any type of buried conduit used to convey and collect contaminated groundwater by gravity flow. Subsurface drains essentially function like a line of extraction wells and therefore can perform many of the same functions as wells. However, use of subsurface drains is generally limited to shallow depths (less that 40 feet) and requires lengthy trench excavation. Because of the depth of contaminated groundwater at the Conrail Site (greater than 100 feet BGS), subsurface drain collection was not retained for further consideration.

2.4.2.6 Groundwater Treatment

Potential groundwater treatment technologies can be employed either on site or off site using one of the following general approaches:

- On-site treatment using mobile treatment systems;
- On-site construction and operation of treatment systems;
- Pretreatment of contaminated groundwater, followed by discharge to a publicly owned treatment works (POTW) or to a surface water body;
- *In situ* treatment; and
- Collection and transportation of contaminated groundwater to an off-site treatment facility.

The groundwater treatment technology process options that have been identified and screened for the Conrail Site fall into four categories:

- Physical/chemical treatment processes;
- Biological treatment processes;

- Thermal treatment processes; and

- *In situ* treatment processes.

Processes which fall under the first three categories require collection of groundwater from the aquifer prior to treatment. Treatment for these options would take place above-ground at an on-site or off-site treatment system. However, *in situ* processes (which may be physical/chemical, or biological in nature) may be applied to groundwater while the groundwater remains in the aquifer, and therefore do not require groundwater collection. Each process option is discussed below.

Physical/Chemical Treatment Processes

Physical treatment processes can be used to separate contaminants from groundwater by isolating, segregating, or changing the physical form of the contaminants, whereas chemical treatment processes alter the chemical structure of the constituents to detoxify or convert them to a form that is less hazardous than the original constituents. Further, the altered constituents may be easier to remove from the waste stream. Physical and chemical treatment processes are utilized to treat inorganic as well as organic groundwater contaminants, particularly those that are either non-biodegradable or resistant to biodegradation.

- **Sedimentation** is the removal of particulate matter, chemical floc, and precipitates from suspension through gravity settling. Settling basins may be constructed in a wide variety of shapes and flow mechanisms and are designed to minimize large-scale turbulence, allowing for the efficient removal of particulates. Sedimentation is often used in conjunction with other treatment process options and may help to minimize interferences with proper treatment system operation by preventing clogging and/or fouling. For this reason, sedimentation was retained for further consideration.

- **Filtration** is a treatment process whereby suspended solids (and any associated contaminants) are removed from solution by forcing the fluid through a filtering medium. The filtering medium may be a fibrous fabric (paper or cloth), a screen, or a bed of granular material. Filtration can also be used as a pretreatment for air stripping, carbon adsorption, or ion exchange to reduce the potential for clogging or overloading of these processes. For these reasons, filtration was retained for further consideration.

- **Air Stripping** involves passing groundwater through a contacting vessel to maximize air/water contact and allow volatile organic constituents in the water to transfer to the air phase. The air stream may require treatment (e.g., vapor-phase carbon adsorption) prior to discharge to the atmosphere to remove vapor-phase volatile organic constituents. The treated aqueous stream may require further treatment (e.g., carbon adsorption) prior to ultimate discharge. Air stripping was retained for further evaluation.

- **Membrane Separation** technologies separate solutes or contaminants from liquids through the use of semipermeable membranes. Semipermeable membranes function by selectively rejecting contaminants based on pore size, charge, or through co-precipitation. Membrane separation technologies include reverse osmosis, ultrafiltration, and electrolysis. These technologies are effective in removal of specific ions such as salts, but are not applicable to VOCs. For this reason, membrane separation was not retained for further consideration.

- **Phase Separation** is used for separating solid/liquid or liquid/liquid suspensions with different specific gravities. It includes oil separation and centrification. These technologies are not applicable to the contaminants of concern at the Conrail Site, and, therefore, phase separation was not retained for further consideration.

- **Precipitation/Coagulation/Flocculation** is a proven water treatment process that removes heavy metals and colloidal and dissolved solids from contaminated groundwater. The addition of precipitating agents and coagulants converts metals to forms that are less soluble in water. The metals and any dissolved or suspended solids agglomerate to form large particles that can be readily removed from the groundwater by a clarification or filtration process. The performance of the process is affected by chemical interactions, temperature, pH, solubility variances, and mixing effects. Precipitation/coagulation/flocculation is often used in conjunction with other treatment process options and may help to minimize interferences with proper treatment system operation by preventing clogging and/or fouling. For this reason, precipitation/coagulation/flocculation was retained for further consideration.

- **Ion Exchange** is a process by which toxic ions are removed from the waste stream and replaced with relatively harmless ions held by ion exchange material. A variety of ion exchange materials can be used including natural and synthetic zeolites and organic resins (the most commonly used material). This process can be used to remove metals, chlorides, nitrates, sulfates, and ammonium compounds from solution. Since these are not contaminants of concern at the Conrail Site, ion exchange was not retained for further consideration.

- **Chemical Reduction** involves addition of a reducing agent that lowers the oxidation state of a substance in order to reduce toxicity or solubility or to transform it to a form that can be easily handled. As discussed in Soil Treatment (Section 2.4.1.5), chemical reduction is more applicable to metals such as hexavalent chromium. For this reason, chemical reduction was not retained for further consideration.

- **Chemical Oxidation** is used primarily for detoxification of cyanide and for treatment of dilute wastestreams containing oxidizable organics. Aldehyde, mercaptans, phenols, benzidine, unsaturated acids, and certain pesticides have been successfully treated by this method. Chemical oxidizers utilized include hydrogen peroxide, potassium permanganate, chlorine, ozone, and chlorine dioxide. Chemical oxidation is not commonly used to treat chlorinated VOCs, and was not retained for further evaluation.

- **Activated Carbon Adsorption** removes organics from aqueous contaminated groundwater streams by adsorbing the compounds onto the large internal pore surface area of activated carbon. The process has been demonstrated on a variety of organics, particularly those exhibiting low solubility and high molecular weight. Activated carbon can be used in a treatment column or added in a powdered form to contaminated water. Carbon adsorption can be readily implemented at hazardous waste sites and can remove dissolved organics from aqueous wastes to levels below 1 part per billion (ppb). Because low effluent concentration of contaminants can be achieved through this process, it is often used for secondary treatment, following another primary process option, to achieve required discharge limitations. Cleanup efficiency, however, can be reduced if high concentrations of suspended solids are present in the ground water. Activated carbon adsorption was retained for further evaluation.

- **Ultraviolet Photolysis/Ozonation.** Innovative treatment technologies such as Ultrox used ultraviolet radiation/ozonation processes. These processes usually combine ultraviolet (UV) light, ozone, and hydrogen peroxide to chemically oxidize organic compounds present in water. Complex organic molecules are broken down into a series of less complex molecules, eventually terminating with carbon dioxide and water. Off-gasses may need to be collected/treated. UV radiation/ozonation treatment is effective in treating a wide variety of chlorinated hydrocarbons and other toxic organics with double carbon bonds. The treatment is only effective on clear water, so pretreatment of influent water may be required. Ultraviolet photolysis/ozonation was not retained for further evaluation, since it would not be effective for CCL_4.

- **Dechlorination** is a treatment process that uses a chemical reaction to replace the chlorine atoms in chlorinated aromatic molecules (such as PCP, dioxins, and furans) with an ether or hydroxyl group. By stripping the chlorine atoms, the toxicity of the chlorinated aromatic compounds is reduced or eliminated. Since the contaminants of concern at the Conrail Site do not have an aromatic structure, dechlorination was not retained for further consideration.

- **Chemical Neutralization/Detoxification** is used to increase or reduce the pH of a wastewater stream. Alkaline wastewater may by neutralized with hydrochloric acid, carbon dioxide, sulfur dioxide, and, most commonly, sulfuric acid. Acidic wastewaters may be neutralized with limestone or lime slurries, soda ash, caustic soda, or anhydrous ammonia. Often, a suitable pH can be achieved through the mixing of acidic and alkaline process wastewaters. Selection of neutralization agents is based on cost, availability, ease of use, reaction byproducts, reaction rates, and quantities of sludge formed. The adjustment of pH may be necessary to optimize treatment system performance. For this reason, chemical neutralization/detoxification was retained for further consideration.

Biological Treatment Processes

CCl_4 and TCE are not readily degradable, and degradation that does take place may yield hazardous byproducts (e.g., vinyl chloride). Therefore, biological processes were not retained for further consideration. The biological treatment process options that were identified, but screened out, are discussed below.

- **Fixed-Film Bioreactor.** A fixed film bioreactor contains a high-surface-area medium on which a fixed film of biomass grows. Contaminated water is trickled over the biomass film to allow for sufficient contaminant and oxygen mass transfer. Because of mass transfer limitations, overall biomass film surface area controls removal efficiencies. The medium needs large voids to allow for adequate air circulation and to avoid clogging from the sloughing of biomass. The biomass that accumulates from sloughing must be settled in a clarifier and disposed of. Typical media used include large stones or plastic packings.

- **Activated Sludge.** In the activated sludge process, wastewater is mixed in a basin with a suspended biomass floc and aerated. This mixture is called the mixed liquor. The mixed liquor remains in the basin for a specified period of time, to allow for biodegradation, and then is settled in a clarifier. A fraction of the sludge that settles is recycled to the basin and the rest is disposed of. The fraction of sludge that is recycled determines the solids retention time of the system and controls removal efficiencies. Since this process is not controlled by mass transfer limitations, higher removal efficiencies can be obtained.

Thermal Treatment Processes

Organic contaminants in groundwater can be destroyed using a thermal process called supercritical oxidation.

- **Supercritical Oxidation,** a type of wet air oxidation, breaks down organic constituents in a high-temperature, high-pressure aqueous environment. It utilizes the unique properties of water at pressures in excess of 218 atmospheres combined with temperatures above 500°C to chemically oxidize organic wastes at high levels of efficiency (greater than 99%). This treatment process has high energy requirements and is more applicable to concentrated waste streams. Since the groundwater contamination at the Conrail Site is relatively dilute, supercritical oxidation was not retained for further consideration.

***In situ* Treatment Processes**

In situ treatment processes are utilized to treat/remove contamination in groundwater without the use of groundwater collection systems. Applicable *in situ* treatment process options are discussed below.

- **Air Sparging** reduces concentrations of organic compounds in groundwater by injecting air below the water table. The air bubbles contact contaminants, causing them to volatilize and migrate to the vadose zone. Further treatment, usually soil vapor extraction, would be required to remove contaminants from the vadose zone. Air sparging is particularly effective on VOCs with relatively low water solubilities. Air sparging was retained for further evaluation.

- **Steam Injection.** In steam injection, compressed steam is injected into the groundwater and/or NAPL layer. The steam than percolates upwards and strips the contaminates, carrying them to the vadose zone. As with air sparging, a soil vapor extraction system would be required to remove the contaminants from the vadose zone. Although this process is similar to air sparging, steam injection is more effective in removing less volatile organics and NAPL layers. Steam injection was retained for further evaluation.

- ***In Situ* Bioremediation.** As discussed in the soil remediation technologies, *in situ* bioremediation uses indigenous or introduced aerobic or anaerobic microorganisms to break down organic compounds in the groundwater and soil. *In situ* bioremediation relies on creating favorable aerobic conditions to improve aerobic microbial processes. This method involves optimizing environmental conditions by providing an oxygen source and nutrients, which are delivered to the subsurface through an injection well or infiltration system to enhance microbial activity. Indigenous microorganisms can generally be relied upon to degrade a wide range of compounds, given proper nutrients and sufficient oxygen. Specially adapted or genetically manipulated microorganisms are also available and may be added to the soil/groundwater zone. Although *in situ* bioremediation is effective in many applications, the contaminants of concern at the Conrail Site, i.e., chlorinated solvents, are not readily degradable and may yield toxic degradation byproducts (e.g., vinyl chloride). Therefore, *in situ* bioremediation was not retained for further consideration.

2.4.2.7 Groundwater Discharge

Four technologies were identified and screened for groundwater disposal: reinjection to groundwater, publicly owned treatment works (POTW), deep well injection, and surface water discharge. These technologies are discussed below.

Aquifer Reinjection

Treated groundwater may be reinjected into the aquifer from which it was withdrawn. Reinjection can occur either upgradient or downgradient of the contaminant plume. Upgradient injection can be used to help direct the flow of contaminated groundwater toward extraction wells. Downgradient injection may act as a physical barrier to contaminant migration. Injection may also be used to enhance *in situ* soil flushing (discussed in Section 2.4.1.5). This option was retained for further evaluation.

POTW

Contaminated groundwater from the site may be pretreated on site and then discharged to a nearby POTW for final disposal. The City of Elkhart POTW is located east of the site and may be able to accept treated groundwater. However, the reserve capacity of the POTW above its average daily flow is somewhat limited. Disposal at a POTW was retained for further consideration.

Deep Well Injection

Deep well injection is a method used for disposal of highly contaminated or very toxic wastes not easily treated or disposed of by other methods. The use of deep well injection is limited geographically because of geological requirements of the system. There must be an extensive impervious caprock stratum overlying a porous stratum that is not used as a water supply or for other withdrawal purposes. Pretreatment of the waste for corrosion control and especially for the removal of suspended solids is normally required to avoid plugging of the receiving strata. This disposal option would likely not be approved by regulatory agencies, does not provide permanent treatment of the waste stream, and, therefore, was not retained for further consideration.

Surface Water Discharge

Treated groundwater may be discharged to a nearby surface water body. A National Pollutant Discharge Elimination System (NPDES) permit would be required for the discharge. The St. Joseph River, located north of the site, would be a potential receiving body for discharge. This option was retained for further evaluation.

2.5 EVALUATION AND SELECTION OF TECHNOLOGY PROCESS OPTIONS

For the soil and groundwater remedial technology process options that were retained in the initial identification and screening, an evaluation was conducted based upon the criteria of effectiveness, implementability, and cost, which are described as follows:

- Effectiveness - an evaluation of the potential effectiveness of process options in controlling the estimated areas or volumes of media and meeting the RAOs.
- Implementability - an evaluation of the technical and administrative feasibility of a technological process. Processes unable to meet location- and action-specific ARARs will be eliminated from further consideration. Technologies requiring prohibitively extensive permitting will also be eliminated. If sufficient treatment, storage, or disposal capacity is not available for certain off-site options, these also may be discarded.
- Cost - a rough, relative estimate of capital and operating and maintenance (O & M) costs. Cost will be a factor in comparing technologies that can produce similar levels of protection for potential recep-

tors. This criterion plays a limited role in the evaluation of technologies.

These criteria will be used to reduce the list of applicable process options to those that are best suited for the Conrail Site. Where appropriate, only one process option will be selected to represent a given technology type in order to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design.

2.5.1 Evaluation of Soil Technology Process Options

The soil technology process option evaluations are discussed below. Although no action, additional investigation, and institutional actions are GRAs, they are presented as process options in this section for ease of discussion. Also, they are collective actions and it would not be appropriate to evaluate specific process options individually. The selection of representative process options for given GRAs is discussed where appropriate.

2.5.1.1 No Action

No attempt would be made to contain, collect, remove, or treat any of the identified soil contamination at the Conrail Site. This option would rely solely on natural attenuation of the contaminants.

Effectiveness. This option provides no additional effectiveness in reducing volumes of contaminated soil or in protecting human health and the environment, though contaminants may attenuate naturally over a very long period of time.

Implementability. This action is technically implementable but does not meet any of the six waivers for not meeting ARARs set forth in CERCLA. Accordingly, this action would not be acceptable to the public or regulatory agencies.

Cost. There is no cost associated with this action, except for additional monitoring of the LaRue Street area plume, which is not included in the interim action monitoring program.

2.5.1.2 Additional Investigation

Further information searches and/or systematic surface and subsurface sampling would be utilized to identify suspected additional sources of contamination not yet discovered at the Conrail Site. Borings and lead-screen augering may be used to collect soil and/or groundwater samples. Samples would be analyzed for VOCs and any other parameters deemed appropriate during the investigation.

Effectiveness. Additional investigation will provide no protection in itself but will be effective in identifying additional sources of contamination and in further defining the origins of identified groundwater contamination plumes. The identification of additional sources, if they exist, will enhance groundwater remedial actions and reduce the duration of treatment needed to meet groundwater RAOs.

Implementability. Subsurface investigation and sample collection/analysis could be readily implemented. However, actually locating additional sources may be difficult because of the size of the Conrail facility and widespread nature of groundwater contamination beneath the facility. Numerous environmental investigation firms are available for this type of work.

Cost. Investigation efforts require relatively low-moderate capital expenses and no O & M.

2.5.1.3 Institutional Actions

Deed restrictions, fencing, and warning signs would be implemented along with the interim action (as described in Section 1.2.1) to limit access to the Conrail Site and to prevent exposure to soil contamination.

Effectiveness. Institutional actions do not reduce contamination. Access restrictions to prevent exposure to site soils will be limited. Workers at the facility will be exposed to the sources. Since railroad track continues off site in the east and west directions, fencing will not be able to be installed in these areas because of the active use of the railyard. This will allow easy access, and thus the potential for exposure from soil sources by inhalation, dermal contact, and ingestion will still exist. Furthermore, sources will remain in the soil and may continue to contribute to groundwater contamination plumes indefinitely.

Implementability. Contractors to install fences and warning signs are readily available. Deed restrictions can be implemented easily as well. However, legal requirements and authority must be established. Institutional actions may not meet ARARs as a stand-alone GRA. Thus, institutional actions may need to be implemented with other GRAs or must meet at least one of the six waivers set forth in CERCLA as described in Section 2.2.

Cost. The cost of implementing institutional actions is relatively very low.

2.5.1.4 Soil Excavation

Contaminated soil would be excavated using conventional construction equipment adapted to minimize secondary migration of contaminants. Soil sampling would be required upon completion of excavation to verify that remaining soil meets established cleanup goals. Excavation pits would be backfilled with treated soil meeting RAOs or clean fill.

Effectiveness. Excavation is a well demonstrated and reliable technology for the removal of contaminated soil. However, excavation of soils containing VOCs presents the possibility of releasing the volatile contaminants into the atmosphere, in addition to the possibility of generating contaminant-laden dust. During excavation activities, air quality monitoring is required and dust and/or vapor control measures (e.g., foam or water) may be required.

Implementability. Soil excavation is typically a straightforward process requiring no special equipment or materials. However, excavation of the Conrail Site would require the temporary removal and replacement of track. Track removal and replacement could cause scheduling and routing problems for train traffic that actively uses the railyard. Furthermore, excavation of saturated soils would require complex construction procedures (e.g., sheet piling, wet excavation techniques, structural reinforcements, dewatering). Also, a large staging area would be required for temporary stockpiling of excavated soil. Despite these considerations, soil excavation is implementable at the Conrail Site.

Cost. Excavation requires moderate capital cost. Removing and replacing track would require moderate capital costs, depending on the amount of track. Also, there may be high costs associated with rail use delays incurred from track taken out of service. If dewatering is required to excavate soils below the water table, collection and treatment of water would incur additional costs.

2.5.1.5 Incineration

Excavated soil from the shallow TCE source would be incinerated. Although three incinerator process options were retained in the identification and screening section, the rotary kiln process option was selected as a representative incinerator because it is commonly used in remedial applications. Since all three process options are comparable in effectiveness and implementability, selecting a representative process option eases the evaluation process without compromising completeness. If an incineration alternative is selected for implementation the infrared or fluidized-bed incineration process option may be used in place of the rotary kiln process option if justified during the design stage.

Effectiveness. Rotary kiln incineration is a well-proven technology for the treatment of chlorinated organic compounds in soil. This high-temperature technology (a technology having the ability to heat soil to greater than 1,000° F) has been used to remediate numerous hazardous waste sites. The high-temperature operation virtually guarantees destruction of organic constituents. Destruction and removal efficiencies of 99.99% for the chlorinated organic compounds found at the Conrail Site have been well demonstrated by both mobile and fixed incineration systems.

Before the beginning of on-site incineration activities utilizing a mobile system, a trial burn would be required to demonstrate that the system meets applicable federal and state environmental criteria.

On-site thermal systems would require careful monitoring of feed-stream characteristics. Development of reliable materials handling systems would be required to transport, prepare, and feed the soil to the thermal unit. Materials handling and preparation systems for on-site thermal systems are often complex and may add considerably to the time requirements for thermal treatment; increased downtime could also be a result.

Implementability. Implementation of an on-site mobile incineration system may be difficult due to the permitting that would be required. Approval of all necessary permits pertaining to the construction and operation of an on-site mobile incineration system would be required before any site preparation/construction activities are begun. Permitting of thermal incineration systems has historically been difficult and has proven to be a costly and lengthy procedure. Once all the proper permits are secured, the following activities would have to be implemented in the order specified:

- Installation of the transportable thermal unit;
- Startup and shakedown operations; and
- Trial burns.

As with the task of permitting the system, the basics of system mobilization and trial burns are frequently quite lengthy. Mobilization and construction of the unit could take an estimated 12 to 16 weeks. The startup and shakedown operations would be conducted until trial burns demonstrate that the thermal incineration system meets all federal and state environmental regulations.

The incinerator ash could be disposed of on site after sampling verified that the soil was no longer classified as a hazardous waste. The presence of metals in ash can result in disposal difficulties, but metals are not anticipated to be significant in Conrail Site soils.

After completion of remedial activities, demobilization and decontamination of the system would be required. This task would take an estimated two to six weeks.

An additional factor to be considered would be community relations. Implementation of a program of on-site incineration could generate community opposition.

Cost. Estimated unit costs for on-site thermal incineration range from $250/ton to $350/ton. Included in this unit cost estimate are the following items:

- Site preparation (preparation of a graded, graveled work area; concrete pads; and all-weather access roads);
- System mobilization/demobilization;
- Labor; and

- Utilities.

Overall the cost of incineration is relatively high in capital and moderate in O & M.

2.5.1.6 Thermal Desorption

Excavated soil would be treated using thermal desorption.

Effectiveness. Low-temperature thermal desorption is a relatively new technology. Bench-, pilot-, and several full-scale demonstrations have been performed on soil containing VOCs such as TCE; a 99.9% VOC removal efficiency was typically achieved during these demonstrations. Below is a brief summary of selected applications of the low-temperature thermal desorption technology. All of the thermal desorption systems described here are fully mobile.

- Under contract with the United States Army Toxic and Hazardous Materials Agency (USATHAMA), Roy F. Weston, Inc., performed a pilot- and full-scale demonstration of its Low-Temperature Thermal Treatment (LT^3) system for remediation of VOC-contaminated soil. Greater than 99.9% VOC removal from the soil was demonstrated. Recovered volatiles were destroyed in an afterburner. Stack emissions complied with all federal and state regulations, including those for VOCs, HCl, CO, and particulates.

- The low-temperature thermal aeration (LTTA) system developed by Canonie Environmental Services Corporation (Canonie) has been used to remediate soils containing, primarily, chlorinated solvents and nonchlorinated aromatic hydrocarbons at two EPA Superfund sites: the McKin Superfund site in Gray, Maine, and the Ottatiand Goss/Great Lakes Container Corporation site in Kingston, New Hampshire.

- Chemical Waste Management has developed the X*TRAX Low Temperature Treatment process to remove volatile or semivolatile compounds from a solid matrix. To date, laboratory and pilot-scale systems have demonstrated the effectiveness of the X*TRAX system in separating semivolatile and volatile compounds from a solid matrix.

To determine the remedial effectiveness of thermal desorption, bench-scale equipment is used to predict the expected capability of a full-scale unit to process a given soil matrix with specific contaminants. Pilot-scale testing would not be necessary since data generated from the bench-scale study is typically sufficient to determine the applicability of using a full-scale, low-temperature thermal desorption unit for soil remediation.

Thermal desorption alone, however, would not permanently destroy the chlorinated organics found in the soil matrix at the Conrail Site. Thermal desorption is a mass transfer process in which the VOCs in the soil are transferred into the air stream within the thermal processor/materials dryer. The gases released from the thermal processor/materials dryer would require additional treatment prior to release into the atmosphere. A vapor-phase carbon adsorption system or combustion afterburner could be used to remove the organic compounds from the off-gases. A carbon adsorption system would require periodic replacement and/or regeneration. Depending on the disposal arrangements made for the spent carbon, the organic compounds adsorbed into the carbon may be destroyed. A likely disposal option for the spent carbon would be off-site regeneration in which the organic vapors are destroyed by incineration. If a combustion afterburner were used for treatment of the off-gases from the thermal processor/materials dryer, the organic compounds would be destroyed on site. A permit would be required for the combustion afterburner, and stack emissions would have to be in compliance with all applicable federal and state regulations. Pilot- and full-scale demonstrations of thermal desorption systems utilizing combustion afterburners for treatment of system off-gases were in compliance with federal and state regulations, including those for VOCs, HCl, CO, and particulates.

A typical thermal desorption system design includes a condenser. Condensate from the condenser is composed of water and condensed volatile organics and may contain oil from the heating system. The two-phase condensate is separated in an oil/water separator. The separated oil is stored for future transport and processing off site. The water, with a relatively low concentration of soluble organics, is typically treated using a carbon adsorption system. The treated water is sprayed on the treated soil to cool it and suppress dust generation. The spent carbon from the carbon adsorption system would require periodic replacement and/or regeneration. A likely disposal option for the spent carbon would be off-site regeneration in which the organic vapors are destroyed by incineration.

Implementability. The low-temperature thermal desorption systems currently available are fully mobile and owned and operated by commercial vendors. Permitting of the system would be required, as well as the development of monitoring and analytical procedures and protocols.

Once all the proper permits were secured and site preparation activities (e.g., establishment of utilities) were completed, the thermal desorption units could be mobilized. Typically, the systems are transported on flatbed trailers, and approximately one week is required for setup.

Treated soil could be disposed of on site, assuming that sampling verified that the soil met cleanup goals and was not classified as a hazardous waste. Any treatment residuals (e.g., spent carbon or condensed oil) would possibly have to be managed as a hazardous waste requiring off-site treatment and/or disposal.

Cost. The estimated cost for the bench-scale study necessary to determine the feasibility of utilizing low-temperature thermal desorption for soil remediation is $15,000 to $20,000. Technology-specific treatment costs are estimated to be $100 to $150 per ton (based on 20% moisture content), which are relatively moderate in both capital and O & M.

2.5.1.7 Vapor Extraction and Air Sparging or Steam Injection (*In Situ*)

Contaminated soil sources would be treated in place (*in situ*) using vapor extraction and may be enhanced by using air sparging or steam injection. In this evaluation, air sparging and steam injection process options are coupled with the vapor extraction process option because these two options provide effectiveness in the saturated soil zones, which vapor extraction cannot achieve alone, and also because these options cannot be implemented without a vapor extraction system. These process options used in conjunction provide a more comprehensive option for alternative development that allows for implementation the deep saturated CCl_4 source location (track 69 area), as well as in the unsaturated CCl_4 source area (LaRue Street area), and the relatively shallow unsaturated TCE source area (Tracks 65/66).

Effectiveness. *In situ* vapor extraction is a well-demonstrated technology used to remove VOCs from the vadose or unsaturated zone of soil. This technology has been successfully applied for VOC removal at numerous sites in a wide range of geologic and hydrogeologic conditions. All of the volatile priority pollutants have been successfully extracted with the vacuum extraction process, and applications have ranged from small gas stations to large Superfund sites.

In order for a vacuum extraction system to be successful, the system design would have to take into consideration a number of parameters, including soil permeability, porosity, moisture content, stratigraphy, depth to groundwater, and contaminant chemical properties. The soil should exhibit sufficient air-filled porosity to allow the vacuum and extraction air to do its job of *in situ* stripping of the VOCs from the soil matrix. Water hinders this stripping action since it reduces the air-filled porosity.

Where contaminated soils are saturated with groundwater, as in the case of the CCl_4 source at the Conrail Site, remediation may be more effective if a dual extraction approach is implemented. Dual extraction is a term that describes the process of simultaneously extracting groundwater and organic vapors from the vacuum extraction wells. This technique would lower the water table, thereby increasing the effective unsaturated zone of soil in which the vacuum extraction process could vaporize organic contaminants. Simultaneous extraction of groundwater and vapors under vacuum enhances recovery of groundwater contaminants and reduces the time frame for total cleanup. Air sparging and steam injection enhance groundwater contaminant recovery as well, especially in the saturated zone. In air sparging, compressed air is injected into the saturated zone and percolates upwards through the saturated soil. Contaminants are stripped from the groundwater and desorbed from the saturated soil. Steam injection is similar except compressed steam is used instead of air. Both are effective in mobilizing NAPLs, though steam injection works better on less volatile contaminants because of the high temperature of the steam.

Air and/or groundwater extracted from a vacuum extraction well would require proper handling and may require treatment prior to discharge since vacuum extraction is a mass transfer process and would not destroy the chlorinated organics found at the Conrail Site. The contaminated air stream would most likely be treated using vapor-phase activated-carbon units. These units would require periodic replacement and/or regeneration. A likely disposal option for the spent carbon would be off-site regeneration so that the organic compounds adsorbed on the carbon could either be recycled or destroyed. Any contaminated groundwater extracted in conjunction with an *in situ* vapor extraction system would most likely be treated and/or disposed of utilizing the technology selected during this study for remediation of the groundwater beneath the Conrail Site.

Implementability. An *in situ* vapor extraction system would be relatively simple to construct and operate. The necessary materials, equipment, and personnel are readily available through a number of vendors. Permitting of the system would be required as well as the development of monitoring and analytical protocols and procedures. The placement of piping beheath rail tracks may require special equipment or techniques, but should still be implementable. Most of the piping could probably be placed between and parallel to tracks.

Minimal maintenance of the system would be required. Sampling of the off-gases and wastewater would be required to ensure regulatory compliance. The activated carbon units would require replacement when breakthrough has occurred on the primary units. (The primary vapor-phase carbon units would be followed by secondary or backup carbon units to ensure that contaminants are captured should breakthrough occur in the primary unit.)

Since this technology is an *situ* treatment, it does not involve the placement of a waste restricted from land disposal under the RCRA regulations, and, therefore, the RCRA land disposal restrictions would not apply to the soil. However, any residuals generated from the treatment of soils (e.g., activated carbon and recovered groundwater) would have to be managed as RCRA hazardous waste, subject to the land disposal restrictions.

Cost. The cost for the pilot-scale study required to determine the effectiveness of *in situ* vapor extraction is approximately $50,000. Treatment costs for *in situ* vapor extraction are estimated to be $75 to $100 per cubic yard. Additional costs would be required for the activated carbon regeneration. Overall, this process option has relatively moderate capital and O & M costs.

2.5.1.8 Soil Flushing

A flushing solution would be injected into the contaminated soil and recovered with extraction wells. The recovered elutriant would be treated on site, then reinjected.

Effectiveness. Soil flushing has potential effectiveness at the Conrail Site. Characteristics of the site contaminants and soil are promising for this application. The contaminants of concern at the Conrail Site are primarily VOCs, they are not mixed or varied in composition, and they have favorable partitioning coefficients. Also, the site soil is fairly consistent in composition, low in organic content, and has a high permeability.

Although soil flushing appears promising, there are some considerations that may diminish effectiveness. Soil/solvent reactions may reduce contaminant mobility. Unfavorable flushing fluid characteristics such as high toxicity or volatility, difficult recovery, and poor treatability may pose health risks and recovery/treatability problems. Also, the site hydrology must permit recapture of the elutriant. To address these issues, a pilot-scale treatability study would be necessary to adequately design a full-scale system.

Very little data exists regarding the effectiveness of this technology in full-scale applications. Therefore, the effectiveness of soil flushing for Conrail Site soils cannot be predicted with great confidence.

Implementability. There are no technological impediments to implementing a soil flushing system. The only equipment required is injection and recovery wells and conventional treatment systems. An NPDES permit would be required, however to inject the elutriant into the ground.

Cost. The cost of soil flushing is moderate in both capital and O & M.

2.5.1.9 Off-site Disposal

Excavated soils would be treated to meet land disposal restrictions, if necessary, and hauled to an off-site sanitary or secure landfill as appropriate.

Effectiveness. Off-site disposal is effective as long as land disposal restrictions are met and the appropriate type of landfill is chosen. Soil categorized as nonhazardous may be disposed of in sanitary or commercial landfills whereas hazardous waste soil must be disposed of in a secure RCRA facility. Appropriate landfill selection will ensure that future migration and potential exposure of contaminants will be minimized by means such as proper landfill location (low permeable soils, low water table), lining and capping, and leachate collection/ treatment systems. Several short-term risks are associated with off-site disposal. Local track traffic will increase from the contaminated soil being hauled off-site. This traffic will result in increase noise and the potential of an accidental spill of the contaminated soils.

Implementability. Land disposal of contaminated soils has historically been a popular remedial alternative; this procedure often represented the quickest, simplest approach to remediating a site. More recently, the trend has been toward utilizing treatment technologies to remediate contaminated sites. This trend is attributable to the following two factors:

- Section 121 of SARA requires that preference be given to remedial action that "...permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances." SARA further states "that off-site transport and disposal...without such treatment should be the least favored alternative remedial action where practical treatment technologies are available."

- In 1984, Congress passed the Hazardous and Solid Waste Amendment of 1984 (HSWA), which mandated stringent new land disposal limitations, also known as RCRA land disposal restrictions.

The RCRA land disposal restrictions may be applicable to the soils at the Conrail Site. Under the land disposal restrictions, the soil from the Conrail Site cannot be land disposed if it is determined to exhibit the characteristic of toxicity, based upon leachate from the Toxicity Characteristics Leaching Procedure (TCLP) assay. Maximum concentrations CCl_4 and TCE in TCLP extract are both 500 $\mu g/L$. TCLP analyses are not available for site soils; however, total soil concentrations indicate that treatment of the soils may be required prior to land disposal. Soils treated to below-TCLP levels mandated by the land disposal restrictions would still require appropriate disposal.

Cost. The cost of off-site disposal is moderate to high capital with no O & M.

2.5.2 Evaluation of Groundwater Technology Process Options

The groundwater technology process option evaluations are discussed below. Although no action and institutional actions are GRAs, they are presented as process options in this section for ease of discussion. Also, they are collective actions and it would not be appropriate to evaluate specific process options individually.

Sedimentation, filtration, precipitation, and chemical neutralization/detoxification physical/chemical treatment process options were retained, but are not evaluated separately. Since these process options do not provide primary treatment/removal of the contaminants of concern, but may be required as pretreatment for other primary treatment process options, they are considered in the evaluations of the primary treatment process options and alternatives where they are needed. The selection of representative process options for given GRAs are discussed where appropriate.

2.5.2.1 No Action

No attempt would be made to contain, collect, remove, or treat any of the identified contaminated groundwater at the Conrail Site. This action would rely solely on natural attenuation of the contaminants.

Effectiveness. This action provides no additional effectiveness in reducing volumes of contaminated groundwater or in protecting human health and the environment, although contaminants may attenuate over a very long period of time.

Implementability. This action is not readily implementable and does not meet any of the six waivers for not meeting ARARs set forth in CERCLA. Accordingly, this action would not be acceptable to the public or regulatory agencies.

Cost. There is no cost associated with this action.

2.5.2.2 Additional Investigation

Information searches and groundwater sampling would be conducted to identify additional sources of contamination not yet discovered at the Conrail Site. Groundwater samples would be collected from existing and/or new monitoring wells and analyzed for VOCs and any other parameters deemed appropriate during the investigation.

Effectiveness. As discussed for soils, additional investigation will provide no protection in itself but will be effective in identifying additional sources of contamination and in further defining the origins of identified groundwater contamination plumes. The identification of additional sources, if they exist, will enhance groundwater remedial actions and reduce the duration of treatment needed to meet groundwater RAOs.

Implementability. Additional investigation is readily implemented. Many environmental investigation firms are available for this work. However, locating additional sources may be difficult because of the size of the Conrail facility and widespread nature of groundwater contamination beneath the facility.

Cost. Investigation efforts require relatively low-moderate capital expenses and no O & M.

2.5.2.3 Institutional Actions

Deed restrictions, well abandonment, and use of an alternate water supply would be implemented to limit exposure to contaminated groundwater. The alternate water supply could be provided to residences or businesses whose private wells have been impacted by site contamination, or could be provided to all groundwater users in the site area as a preventive measure, to protect against potential future contaminant migration. A groundwater monitoring program would be established to assess groundwater contaminant concentrations throughout the time frame of any remedial action. Air monitoring would be conducted to determine if significant concentrations of VOC vapors are accumulating in buildings on and downgradient from the Conrail railyard.

Effectiveness. Institutional actions do not reduce contamination. As in the No Action GRA, institutional actions, if implemented without other actions, rely on the natural attenuation of the contaminants found in the groundwater. Contaminants will continue to migrate off site. Health risks posed by contaminants remaining in site groundwater would continue unabated. Deed and use restrictions, well abandonment, and the installation of an alternate water supply will be effective in preventing exposure to the contaminated groundwater. The effectiveness of an alternate water supply was established in the Phased Feasibility Study for the Conrail Site (E & E 1991), and over 500 residences will be connected to the Elkhart municipal water supply system under the interim action for the site. The connection of additional groundwater users in the area to the Elkhart municipal supply would be effective in preventing exposure through groundwater use in the event that contamination spreads to other presently unimpacted areas.

Groundwater monitoring is effective in assessing future site conditions on an on-going basis and will be an integral part of any remedial effort. By including groundwater monitoring, the effectiveness of any selected remedial action can be evaluated while the action is being implemented. Air monitoring is effective in assessing whether significant VOC concentrations are accumulating in buildings, and hence the need for any vapor abatement actions.

Implementability. Institutional actions are readily implemented. This is demonstrated in the implementation of institutional actions in the Interim Action as outlined in the SOW of the Unilateral Administrative Order for Remedial Design and Remedial Action. Although institutional actions may be effective and are readily implemented, they may not meet ARARs as a stand-alone GRA. Thus, institutional actions may need to be implemented with other GRAs or must meet at least one of the six waivers set forth in CERCLA as described in Section 2.2.1.

Cost. Institutional actions may vary in cost, but are usually relatively low in both capital and O & M. Deed restrictions are relatively very low in capital and have no O & M costs. Groundwater monitoring and air monitoring are relatively low in both capital and O & M. An exception to the relatively low cost is use restriction through the installation of an alternate water supply system. An alternate water supply system is relatively high in capital cost, although O & M cost would be relatively low compared to other water supply options (e.g., bottled water or the filter units currently at individual homes).

2.5.2.4 Vapor Abatement

In the event that significant VOC vapor concentrations, originating from site groundwater, are discovered in buildings, abatement actions would be necessary. Actions would include sealing floors/basements and/or venting the buildings. It should be noted that no effects have been made to date to measure vapors, and that actual abatement actions would depend upon a number of factors presently unknown, including VOC vapor concentrations and the type of building(s) affected. Specific actions would have to be determined at the time that the need for vapor abatement becomes apparent.

Effectiveness. Vapor abatement actions would be effective in reducing contaminant migration into buildings (sealing) or reducing the levels of VOCs that accumulate (venting).

Implementability. Vapor abatement actions would be readily implementable, using commonly available materials and equipment and using standard procedures. Abatement actions at individual buildings would have to be performed to minimize any inconveniences to building occupants and to minimize any negative impacts to the buildings.

Cost. Costs for vapor abatement actions cannot be ascertained at this time because the need for such action has not yet been established, the specific types of actions that would be required have not been determined, and the number of buildings requiring action (if any) has not been determined.

2.5.2.5 Extraction Wells

Groundwater would be pumped from the aquifer to either contain contaminated plumes or completely restore the aquifer. The groundwater collected during pumping would require treatment and disposal.

Effectiveness. Extraction wells are effective in both containment and restoration of aquifers. The results from the risk assessment together with the installation of an alternate water supply being implemented in the interim action suggest that the additional effectiveness over institutional actions is minimal.

Implementability. The nature of the aquifer beneath the Conrail Site may limit implementability, particularly for restoration. In general, restoration of the aquifer requires the removal of large volumes of contaminated groundwater because of mass transfer limitations. During extraction, contaminants adsorbed to the soil do not have time to reach equilibrium concentrations with the groundwater in the pores and consequently, the extracted groundwater is low in concentration.

Thus, extraction of many pore water volumes is needed to achieve MCLs for equilibrium conditions. This requires a lengthy extraction period. The affected aquifer beneath the Conrail Site is very large, permeable, maintains enormous flow of groundwater, and is readily recharged during pumping. To ensure the complete capture of all contaminated plumes throughout the Conrail Site, a large network of extraction wells at various aquifer depths, continually pumping at extremely high rates would be necessary due to the significant recharge. Because of the relatively narrow width of the contaminated plume leaving the Conrail facility, facility containment represents a more implementable action. Regardless, alternatives with both containment and restoration are developed and analyzed later in this report.

Cost. The cost for extraction wells is relatively moderate in terms of capital and low in O & M. However, these costs do not reflect piping connections to treatment facilities, should the collection system extend over a large area. Furthermore, these costs do not include the substantial capital costs for extracted groundwater treatment and disposal facilities.

2.5.2.6 Air Stripping

Extracted contaminated groundwater would be passed through air stripping units. The treated water would require disposal.

Effectiveness. The use of air stripping is well-demonstrated in removing volatile organics from groundwater. This treatment technology would effectively reduce the concentration of VOCs including TCE and CCl_4) from groundwater extracted at the Conrail facility to acceptable levels. Air stripping is routinely used to treat groundwater containing volatile chlorinated organics. Its effectiveness is generally contaminant-specific and not influenced by the quality of the water. Air stripping would be expected to readily treat the extracted groundwater to attain or exceed the discharge standards. No downstream "polishing" with liquid-phase carbon adsorption is expected to be required. Should groundwater containing higher levels of chlorinated organics be encountered during the remediation, the operational parameters, e.g., the air and groundwater flow rates, could be adjusted so that the effluent would continue to meet the discharge standards.

Air stripping, alone, however, would not permanently destroy the chlorinated organics. Air stripping is a mass transfer process in which the volatile chlorinated organics in the groundwater are transferred to the air flowing through the tower. The air effluent from the tower would then require additional treatment prior to release to the atmosphere. A vapor-phase carbon adsorption unit would most likely be used in conjunction with the air stripper to remove the chlorinated organics from the effluent air. The activated carbon in the unit would require periodic replacement and/or regeneration, which would contribute to the total treatment cost. Depending on the arrangements made for the activated carbon disposal, the chlorinated organics adsorbed to the carbon may be permanently destroyed. A likely disposal option would be off-site regeneration in which the desorbed organic vapors are incinerated, resulting in their permanent destruction.

Pretreatment of the groundwater is required to prevent potential plugging or fouling associated with the high iron and manganese concentrations in the groundwater. Pretreatment costs must be added to the groundwater followed by precipitation in a sedimentation basin. This will increase the cost of treatment.

Implementability. An air-stripping treatment system is relatively simple to construct and operate. Few technical difficulties or unknowns are expected to be encountered during construction and operation since the technology is well established. The necessary materials, equipment, and personnel are readily available through a variety of vendors. Maintenance requirements on the tower should be minimal and would include periodic inspection of the air-stripper column bed for plugging and bacterial growth. Power consumption should not be excessive because of the relatively low air flow rates required. The only major issue related to the implementation of this treatment option is the need to make arrangements for disposing of the spent activated carbon from the vapor-phase carbon adsorption unit. Any groundwater treatment residuals (e.g., the spent carbon) are classified as a RCRA hazardous waste (F001) and subject to the land disposal restrictions associated with the RCRA-listed waste it contains. The spent carbon must, therefore, either meet the established treatment standards or be delisted under RCRA before disposal. Delisting would not be considered due to the small quantity of waste expected to be generated over the lifetime of the treatment process. It is expected that the spent carbon would require incineration or thermal desorption followed by vapor-phase incineration to destroy the adsorbed organics prior to final disposal. Three incineration or regeneration facilities are located less than 400 miles from the Conrail facility and could accept the spent carbon if it met their acceptance criteria.

Cost. The capital cost for air stripping is relatively moderate in both capital and O & M.

2.5.2.7 Activated Carbon Adsorption

As a primary treatment, extracted contaminated groundwater would be passed through an activated carbon adsorption unit. The treated water would require disposal. As a secondary treatment, vapor-phase contaminated water from air stripping or vapor extraction systems would be passed through an activated carbon adsorption unit.

Effectiveness. Carbon adsorption is a well-demonstrated technology for removal of organic contaminants in groundwater. As carbon adsorption is routinely used to treat groundwater (or other drinking water sources) containing chlorinated organics, it would be expected to readily remove all the chlorinated organics from the extracted groundwater. Continuous carbon treatment completely removes organic compounds from the aqueous solution until the column becomes saturated. Slugs of groundwater containing higher or lower levels of chlorinated organics would not affect effluent quality, although total bed capacity (i.e., time to saturation) would vary.

Carbon adsorption is also a well-demonstrated technology for removal of vapor-phase organic contaminants like those generated during air stripping and vapor extraction operations. Vapor-phase treatment with carbon is actually more effective than aqueous- phase treatment. Significantly greater mass of contaminants per mass of carbon is removed in the vapor phase than in the aqueous phase. Also, clogging and fouling are less likely to occur.

Carbon adsorption alone, however, would not permanently destroy the chlorinated organics. Carbon adsorption is a mass-transfer process in which organic compounds are transferred to the activated carbon. The activated carbon would have to be replaced periodically and the spent carbon regenerated and/or disposed of. A likely disposal option would be off-site regeneration in which the desorbed organic vapors are destroyed by incineration.

Implementability. A carbon adsorption treatment system would be relatively simple to construct and operate. Because the technology is well established, few technical difficulties or unknowns are expected to be encountered during construction and operation. The necessary materials and equipment are readily available from several vendors. O & M requirements would be minimal and would mainly involve monitoring the effluent for breakthrough.

As with air stripping (with vapor-phase carbon adsorption), the only major issue related to the implementation of this treatment option is the necessity to arrange for the disposal of spent activated carbon. The chlorinated organics may be classified as F001 RCRA waste; the spent carbon would be similarly classified and subject to the land disposal restrictions associated with the RCRA-listed waste it contains. Most likely, the spent carbon would be incinerated or otherwise treated/regenerated by a RCRA-permitted facility.

Cost. The cost for activated carbon adsorption is relatively moderate in capital and relatively high in O & M.

2.5.2.8 Air Sparging

Contaminated groundwater would be treated by an *in situ* air sparging system. A vapor extraction system would be installed in the vadose zone and would remove the air injected into the saturated zone, which rises to the unsaturated zone. Steam injection may be substituted for air sparging in particular circumstances (i.e., for semivolatile organics or NAPL), but air sparging is more applicable to the Conrail Site (i.e., VOC contamination). For ease of discussion, air sparging was chosen as a representative process option for these similar technologies and was used in the evaluation. Should the need for steam injection be justified in the design stage, it may be implemented.

Effectiveness. Air sparging has a potential for achieving superior performance at the Conrail Site. Air sparging acts like an *in situ* air stripper with the relatively permeable site soil column acting as the stripper packing. As discussed earlier in the air stripping effectiveness evaluation, air stripping is a well-demonstrated treatment technology for the primary contaminants of concern (TCE and CCl_4).

The high Henry's Constants and low water solubilities of these VOCs indicate that they will readily volatilize into the injected air as it bubbles to the vadose zone. The mass transfer characteristics of air volatilization are much more favorable than those accomplished in pump-and-treat scenarios. For example, the partitioning coefficients of TCE and CCl_4

suggest that the contaminants will sorb to soil particles rather than dissolve in the groundwater. The pump-and-treat methods are limited by the diffusion of the sorbed contaminants to the groundwater, whereas air sparging allows volatilization to occur from both the sorbed and dissolved contamination.

Certain site conditions may reduce the effectiveness of air sparging. Permeability differentials (i.e., relatively low permeability soil layers such as clay) above the injection zone may cause uncontrolled and accelerated lateral migration of the vapor-phase contamination. This uncontrolled lateral migration may also result in the accumulation of vapors in nearby buildings. These issues should not be of concern at the Conrail Site because borings performed during the RI in the area of the source that would require air sparging indicate that the soil is a fairly permeable silty sand and that only discontinuous clay layers are present. Regardless, precautions should be taken to ensure that the radius effect of the injected air is enclosed by the radius of influence of the vapor extraction system. The effectiveness of air sparging can be seen from case histories of sites with similar soils and contamination which are summarized in Table 2-7.

Implementability. Since air injection and vapor extraction wells are similar in design and installation, air sparging is readily implemented by most soil vapor extraction firms. Also, air injection in the vadose zone is a common enhancement for vapor extraction systems. Both air sparging and vapor extraction systems are relatively simple to construct and operate. The necessary materials, equipment, and personnel are readily available through a number of vendors. Permitting of the system would be required as well as the development of monitoring and analytical protocols and procedures. The placement of piping beneath rail tracks may require special equipment or techniques, but should still be implementable.

Minimal maintenance of the system would be required. Sampling of the off-gases and wastewater would be required to ensure regulatory compliance. The activated carbon units would require replacement when breakthrough has occurred on the primary units. (The primary vapor-phase carbon units would be followed by secondary or backup carbon units to ensure that contaminants are captured should breakthrough occur in the primary unit.)

Cost. Overall, this process option has relatively moderate capital and O & M costs.

2.5.2.9 Aquifer Reinjection

Treated groundwater would be reinjected into the aquifer using injection wells.

Effectiveness. This groundwater disposal process option is effective as long as reinjection is part of the overall treatment scheme. For example, reinjection may be used to enhance *in situ* soil flushing.

Implementability. Reinjection requires permitting and monitoring. Compared to groundwater discharged to surface water, a higher treatment level would be required (most likely, MCLs for drinking water standards). Because of the high mineral concentrations in the groundwater, injection wells would probably need periodic maintenance to remove precipitants.

Injection wells are beneficial at sites where an increased volume of water or an increased hydraulic gradient provides for more rapid groundwater remediation. Both of the factors would result from upgradient injection. However, a sufficient volume of groundwater exists in the aquifer, and groundwater velocities are high enough to promote effective groundwater remediation without reinjection. Furthermore, reinjection is not feasible for the total volume of water to be discharged. Thus, reinjection is not regarded as a viable alternative as the sole means of disposal due to the potential implementability limitations.

Aquifer reinjection was not considered in the development and screening of alternatives within this report. However, computer modeling currently being conducted by E & E to simulate groundwater extraction scenarios will be used to verify whether reinjection provides any benefit towards aquifer remediation. If it is determined that aquifer reinjection would aid in overall aquifer remediation, then the final FS Report will incorporate this option into at least some alternatives retained for detailed analysis.

Cost. The cost of aquifer reinjection is moderate in both capital and O & M. Associated treatment costs may be higher than with other discharge options due to potentially stricter discharge standards.

2.5.2.10 Discharge to POTW

Extracted groundwater would be treated to meet pretreatment standards and discharged to the City of Elkhart POTW by way of a gravity sewer. POTW pretreatment standards would likely be less stringent than NPDES discharge limits, and so less treatment might be required prior to this discharge option.

Effectiveness. The chlorinated VOCs that remain in the groundwater after pretreatment standards are met would most likely volatilize in the sewer line and during treatment at the POTW. Volatilized contaminants would exit the sewer line through vents and would be migrate to surrounding areas. Since the chlorinated VOCs are not readily biodegradable, any additional removal would take place by adsorption to organic solids at the POTW. Any remaining contaminants would then be discharged into the St. Joseph River along with effluent from the POTW. It may be concluded that no true additional treatment/destruction of the contaminants will be provided by the POTW.

Implementability. The city of Elkhart POTW will accept pretreated groundwater from the Conrail Site up to a flow of 1.5 million gallons per day (mgd) for 10 years. The POTW also requires that a 2-mile segment gravity sewer line be installed along U.S. 33 for local commercial facilities to hook up to the sewer system. Though a sewer connection is needed for the Conrail Site anyway, larger sizing of the line would be necessary for the additional hookups.

The 1.5 mgd and 10-year restrictions were established because the POTW has limited reserve capacity for future users. These restrictions would limit remediation system design to a flow below 1.5 mgd and limit future operations and flexibility. Should it be determined in later operations of any Conrail groundwater treatment systems that a 10-year time frame for meeting RAOs is not sufficient, alternate means of disposal would be required.

Cost. Based on the city of Elkhart POTW usage fee schedule, it is estimated that annual cost for disposal would be approximately $520,000. This does not include the high capital cost necessary to install the additional 2 miles of sewer line. Because of the high costs, limited additional effectiveness, and difficulties in implementability, the discharge to POTW process option was not considered in the development and screening of alternatives.

2.5.2.11 Discharge to Surface Waters

Extracted groundwater would be treated to meet National Pollutant Discharge Elimination System (NPDES) effluent standards and discharged to the St. Joseph River. Discharge could be piped to the river or could be transported to the river through existing drainage pathways.

Effectiveness. The St. Joseph River is located within 1-mile of the Conrail facility. The flow of the river is very large. The volume of discharge resulting from any groundwater treatment systems implemented at the Conrail Site would have a negligible effect on flow regimes and ambient water quality of the river. Furthermore, groundwater under the Conrail Site normally discharges into the St. Joseph River due to the hydrology of the area.

Implementability. An NPDES permit would be required before treated groundwater is discharged to the St. Joseph River. Such a permit would specify the levels to which the groundwater should be treated prior to discharge. Overall, there are no significant obstacles to implementation.

However, a water conveyance system would be needed to carry the treated groundwater to the river. Currently, Crawford Ditch is used to convey surface runoff due to precipitation from the Conrail facility. This ditch should be adequate to accept the discharge with little or no modifications, except for erosion control devices. However, the impact of infiltration of water into the ground beneath the ditch would need to be evaluated to determine if groundwater flow could be negatively impacted or if nearby houses/buildings would be impacted (e.g., basement flooding). If these problems or perception problems arise from using the ditch to discharge effluent from an NPL site, the ditch provides an excellent right-of-way for pipe installation to carry the flow.

Cost. If Crawford Ditch can readily accept the discharge with only minor modifications, the cost for this process option would be minor in both capital and O & M. If for perception and security reasons, an enclosed pipe needs to be installed in Crawford Ditch, the cost would be low in both capital and O & M. Otherwise, pipe installation without the right-of-way advantage of Crawford Ditch would be high in capital costs.

Table 2-1

VALUES CONSIDERED TO ESTABLISH PRELIMINARY CLEANUP GOALS FOR GROUNDWATER AND SOIL CONTAMINATION AT THE CONRAIL SITE

Contaminant of Concern	Groundwater (µg/L)				Soil (mg/kg)		
	MCL	Proposed RCRA Action Levels	Risk-Based Concentration[a]	Cleanup Goal[b]	Proposed RCRA Action Levels	Risk-Based Concentration[a]	Cleanup Goal[b]
Primary Contaminants							
Carbon tetrachloride	5	0.3	0.45	5	5	N/A	5
Trichloroethene	5	5	2.9	5	60	3	3
Other Volatile Organic Compounds							
1,1,1-trichloroethane	200	3,000	N/A	–	7,000	N/A	–
1,1-dichloroethene	7	7	0.1	7	10	N/A	–
1,2-dichloroethane	5	5	N/A	–	8	N/A	–
1,2-dichloroethene	70	N/A	N/A	70	N/A	N/A	–
2-butanone (MEK)	N/A	2,000	N/A	–	4,000	N/A	–
Chloroform	100[c]	6	0.95	6	100	N/A	–
Ethylbenzene	700	4,000	N/A	–	8,000	N/A	–
4-Methyl-2-pentanone	N/A	2,000	N/A	–	4,000	N/A	–
Tetrachloroethene	5	0.7	N/A	5	10	N/A	–
Toluene	1,000	10,000	N/A	–	20,000	N/A	–
Vinyl chloride	2	N/A	0.04	2	N/A	0.0008	0.01
Xylenes	10,000	70,000	N/A	–	200,000	N/A	–

[a] Risk-based concentrations were calculated only for compounds that exceed 1×10^{-6} risk.

[b] Cleanup goals are recommended only for certain compounds. Site data do not support establishing goals for other compounds.

[c] This MCL is established for total trihalomethanes - the sum of concentrations for all trihalomethanes should not exceed 100 µg/L.

[d] Cleanup goal established based on standard Contract Laboratory Program detection limit of 0.01 mg/kg.

Note: Proposed RCRA action levels are not final regulatory values (ARARs). However, these levels were considered, along with other numerical values, for establishing appropriate protective cleanup goals for the site.

Key:

– = No cleanup goal recommended based on site data.

N/A = No value available.

Source: Ecology and Environment, Inc. 1994.

Table 2-2

FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS a/

1. Office of Solid Waste
   - Resource Conservation and Recovery Act of 1976 (42 U.S.C. 6901) b/
     a. 40 CFR Part 262, applicable for generators of hazardous waste.
     b. 40 CFR Part 263, applicable for transporters of hazardous waste.
     c. 40 CFR Part 264, applicable for permitted facilities c/, and 40 CFR Part 265, for interim status facilities.
       - Groundwater Protection (40 CFR 264.90-264.101)
       - Groundwater Monitoring, Subpart F (40 CFR 264.98-264.100) d/
       - Closure and Post-Closure (40 CFR 264.110-264.120, 265.110-265.120)
       - Containers (40 CFR 264.170-264.178, 265.190-265.177)
       - Land Treatment (40 CFR 264.270-264.299, 265.270-265.282)
       - Incinerators (40 CFR 264.340-264.999, 265.340-265.369)
       - Land Disposal Restrictions (40 CFR 268.1-268.50)
       - Air emissions from on-site treatment operations (40 CFR 264 Subpart AA and BB).
     d. Statutory requirements, including:
       - Liquids in Landfills (RCRA §3004(c))
       - Minimum Technology Requirements (RCRA §3004(o), 3005(j))
       - Dust Suppression (RCRA §3004(e))
       - Hazardous Waste Used as Fuel (RCRA §3004(q))

2. Office of Water
   - The Safe Drinking Water Act (42 U.S.C. 300(f))
     a. Maximum Contaminant Levels (chemicals, turbidity, and microbiological contamination) (for drinking water or human consumption) (40 CFR 141.11-141.16).
     b. Maximum Contaminant Level Goals (40 CFR 141.50-141.51, 50 FR 46936).

   - Clean Water Act (33 U.S.C. 1251)
     Requirements established pursuant to sections 301 (effluent limitations), 302 (effluent limitations), 303 (water quality standards, including State water quality standards), 304 (Federal water quality criteria), 306 (national performance standards), 307 (toxic and pretreatment standards, including Federal pretreatment standards for discharge into publicly owned treatment works, and numeric standards for toxics), 402 (national pollutant discharge elimination system), and 404 (dredged or fill material) of the Clean Water Act, (33 CFR Parts 320-330, 40 CFR Parts 122, 123, 125, 131, 230, 231,

Table 2-2 (CONT.)

FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS a/

2. Office of Water (Cont.)

233, 400-469). Available ambient Water Quality Criteria Documents are listed at 45 FR 79318, November 28, 1980; 49 FR 5831, February 15, 1984; 50 FR 30784, July 29, 1985; 51 FR 22978, June 28, 1986; 51 FR 43665, December 3, 1986; 51 FR 8012, March 7, 1986; 52 FR 6213, March 2, 1987.

- EPA's Statement of Procedures on Floodplains Management and Wetlands Protection. (40 CFR Part 6 Appendix A) c/

3. Office of Air and Radiation
   - Clean Air Act (42 U.S.C. 7401)
     a. National Emissions Standards for Hazardous Air Pollutants for Asbestos and Wet Dust particulates, (40 CFR 61.140-61.156), and for other hazardous substances (40 CFR Part 61 generally). See also effluent limitations and pretreatment standards for Wet Dust Collection (40 CFR427.110-427.116) and 40 CFR Part 763.
     b. Standards of performance for new stationary sources, including new incinerators (42 U.S.C. 7411), (40 CFR Part 60).
     c. Air emissions from on-site treatment operations (40 CFR 50.1-50.12).

4. Other Federal Requirements
   - OSHA requirements for workers engaged in response or other hazardous waste operations (29 CFR 1910.120).
   - Occupational Safety and Health Act of 1970 (29 U.S.C. 651).
     a. Occupational Safety and Health Standards (General Industry Standards) (29 CFR Part 1910).
     b. The Safety and Health Standards for Federal Service Contracts (29 CFR Part 1926).
     c. The Health and Safety Standards for Employees engaged in Hazardous Waste Operations. (50 FR 45654).
   - Department of Transportation Rules for the Transportation of Hazardous Materials, 49 CFR Parts 107, 171.1-172.558.
   - Endangered Species Act of 1973, 16 U.S.C. 1531. (Generally, 50 CFR Parts 81, 225, 402).
   - Wild and Scenic Rivers Act, 16 U.S.C. 1271.
   - Fish and Wildlife Coordination Act, 16 U.S.C. 661 note.
   - Fish and Wildlife Improvement Act of 1978, and Fish and Wildlife Act of 1956, 16 U.S.C. 742a note.
   - Fish and Wildlife Conservation Act of 1980, 16 U.S.C. 2901. (Generally, 50 CFR Part 83).
   - Farmland Protection Policy Act, 7 U.S.C. 4201. (Generally, 7 CFR Part 658).
   - Rivers and Harbors Act (33 U.S.C. 403).

Table 2-2 (CONT.)

FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS a/

a/ This is the list of potentially applicable or relevant and appropriate requirements found in the October 2, 1985, Compliance Policy with additions. As additional requirements are promulgated, they will be considered potentially applicable or relevant and appropriate and added to this list.

b/ In authorized States, Federal regulations promulgated under RCRA are not applicable as a State requirement until the State adopts those regulations through its own legislative process, but probably would be relevant and appropriate as a federal requirement. Federal regulations promulgated pursuant to the Hazardous and Solid Waste Amendments of 1984, however, are effective immediately in all 50 states, and are potentially applicable as Federal requirements.

c/ 40 CFR Part 264 regulations apply to permitted facilities and may be relevant and appropriate to other facilities.

d/ Only Subpart F groundwater monitoring requirements under 40 CFR 264 are ARAR. The Subpart F groundwater monitoring requirements under 40 CFR 265 are not ARAR.

e/ 40 CFR Part 6 Subpart A sets forth EPA policy for carrying out the provisions of Executive Orders 11988 (Floodplains Management) also 40 CFR 264.18(b) and 11990 (Protection of Wetlands).

Table 2-3

OTHER FEDERAL CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED a/

1. Federal Criteria, Advisories, and Procedures

- Health Effects Assessments (HEAs) and Proposed HEAs, ("Health Effects Assessment for (Specific Chemicals), "ECAO, USEPA, 1985).
- References Doses (RfDs), ("Verified Reference Doses of USEPA," ECAO-CIN 475, January 1986). See also Drinking Water Equivalent Levels (DWELs), a set of medium-specific drinking water levels derived from RfDs. (See USEPA Health Advisories, Office of Drinking Water, March 31, 1987).
- Carcinogen Potency Factors (CPFs) (e.g., Q1 Stars, Carcinogen Assessment Group [CAG] Values), USEPA, OHEA/6008 82/005F, July 1985).
- Waste load allocation procedures, EPA Office of Water (40 CFR Part 125, 130).
- Federal Sole Source Aquifer requirements (see 52 FR 6873, March 5, 1987).
- Public health criteria on which the decision to list pollutants as hazardous under Section 112 of the Clean Air Act was based.
- Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy.
- Advisories issued by PWS and NWPS under the Fish and Wildlife Coordination Act.
- OSHA health and safety standards that may be used to protect public health (non-workplace).
- Health Advisories, EPA Office of Water.
- EPA Water Quality Advisories, EPA Office of Water, Criteria and Standards Division.
- Guidance on Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites (OSWER Dir. 9355.028).

2. USEPA RCRA Guidance Documents

- Interim Final Alternate Concentration Limit Guidance Part 1: ACL Policy and Information Requirements (July, 1987)
  - a. EPA's RCRA Design Guidelines
  - b. Permitting Guidance Manuals
  - c. Technical Resource Documents (TRDs)
  - d. Test Methods for Evaluating Solid Waste
- Health Based Action Levels for Individual Appendix VIII Hazardous Constituents (7/27/90 FR; proposed corrective action rule).

Table 2-3 (Cont.)

OTHER FEDERAL AND STATE CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED a/

3. USEPA Office of Water Guidance Documents

   a. Pretreatment Guidance Documents
   b. Water Quality Guidance Documents
   c. NPDES Guidance Documents
   d. Groundwater/UIC Guidance Documents
   e. Groundwater Protection Strategy (August 1984).
   f. Clean Water Act Guidance Documents

4. USEPA Manuals from the Office of Research and Development

   - SW 846 methods - laboratory analytic methods (November 1986)
   - Lab protocols developed pursuant to Clean Water Act Section 304(h).

a/ This list updates the list of other federal criteria, advisories, and guidance to be considered in the October 5, 1985, Compliance Policy. As additional or revised criteria, advisories, or guidance are issued, they will be added to this list and also considered.

Source: EPA CERCLA COMPLIANCE WITH OTHER LAWS MANUAL; May 6, 1988 (OSWER Directive 9234.1-01).

Table 2-4

SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND REGULATIONS AND STANDARDS TO BE CONSIDERED (TBCS) FOR REMEDIAL ALTERNATIVES FOR THE CONRAIL SITE IN ELKHART, INDIANA

Program Enforcement Area	Response Action	Description of ARARs/TBCs	Regulatory Codes
IDEM OSHWM	Institutional Controls	• Deed Restrictions • Warning Signs • Zoning Controls, Property Condemnation	329 IAC 3.1-10-1(8) 329 IAC 3.1-10-1(8) 329 IAC 3.1-10-1(8)
	Containment	• *In situ* and aboveground containment systems	329 IAC 3.1
	Treatment	• Container management • Tank management • Miscellaneous unit management	329 IAC 3.1-9-1(10) 329 IAC 3.1-9-1(11), 3.1-9-1-3 329 IAC 3.1-9-1
	Disposal	• Land disposal requirements • Record-keeping and manifest requirements	329 IAC 3.1-12,2-21 329 IAC 3.1-8, 3.1-7-1(8)
IDEM OAM	Treatment	• Fugitive Dust Rules • Air Stripping Permit Review and VOC Rules • Emissions permit/registration and controls by IDEM commissioner • VOC emissions • Best available technology (BAT) • Incinerator Rules	326 IAC 6-4, 6-5 326 IAC 2-1, 8-1 326 IAC 2-1-1, 2-1-3 326 IAC 8 326 IAC 8-1-6 326 IAC 4-2
IDEM OWM	Treatment	• On-site carbon adsorption, filtration, air stripping, construction permits	327 IAC 3
	Disposal	• Discharge off site to water, NPDES permit • Discharge off site to POTW-NPDES permit or pretreatment	327 IAC 2, 5-2-2, 5-2-8, 5-2-9, 5-2-10, 5-2-11.1, 5-2-17, and 5-4-2 327 IAC 5-12
	Potable Water Distribution	Indiana Drinking Water Quality Standards	327 IAC 8-2 (identical to SDWA standards)

Key at end of table.

Table 2-4

SUMMARY OF STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND REGULATIONS AND STANDARDS TO BE CONSIDERED (TBCS) FOR REMEDIAL ALTERNATIVES FOR THE CONRAIL SITE IN ELKHART, INDIANA

Program Enforcement Area	Response Action	Description of ARARs/TBCs	Regulatory Codes
DNR	Disposal	• Discharge to St. Joseph River construction in floodway, Flood Control Act	IC 13-2-22
	Groundwater Extraction	• Well registration with the DNR, Division of Water	IC 13-2-6.1
Elkhart County	General	• Proposed Rules and Regulations for Groundwater Protection	Proposed Rules and Regulations, Elkhart County Groundwater Protection Ordinance, May 1, 1989

Key:

IDEM: Indiana Department of Environmental Management
OSHWM: Office of Solid and Hazardous Waste Management
OAM: Office of Air Management
OWM: Office of Water Management
DNR: Indiana Department of Natural Resources
IAC: Indiana Administrative Code
VOC: Volatile Organic Compound
SDWA: Safe Drinking Water Act
NPDES: National Pollutant Discharge Elimination System
POTW: Publicly Owned Treatment Works
--: Not Applicable

Source: Ecology and Environment, Inc. 1994.

Table 2-5

SUMMARY OF IDENTIFICATION AND SCREENING OF PROCESS OPTIONS FOR REMEDIATION OF CONTAMINATED SOIL

General Response Action	Remedial Technology	Process Options	Retained for Further Evaluation?	Comments
No Action	Not applicable	Not applicable	Yes	May be used as baseline comparison.
Additional Investigation	Subsurface sampling, information searches	Soil/groundwater sample collection/analysis	Yes	May enhance effectiveness of site-wide remedial actions. Needed to identify/evaluate suspected additional sources.
Institutional Actions	Access restrictions	Deed Restrictions/ fencing/warning signs	Yes	Does not reduce contamination, but reduces exposure potential.
Containment	Cap	Multimedia Cap	No	Shallow water table and relatively permeable soil reduce effectiveness; implementation difficult because of tracks and active use of the railyard, active use of tracks may compromise cap integrity.
	Vertical Barriers	Slurry walls/sheet piling/grout curtain	No	Shallow water table and deep confining layer reduce effectiveness; implementation difficult because of tracks and active use of the railyard.
	Horizontal Barriers	Grout Injection	No	Shallow water table and depth of contamination reduce effectiveness; implementation difficult because of tracks and active use of the railyard; reliability uncertain.
Removal	Excavation	Soil Excavation	Yes	Allows removal of contaminated soil from site for treatment/disposal.
Treatment	Physical/Chemical Treatment	Stabilization/ Solidification	No	More appropriate for nonvolatile inorganics, mixing and curing or setting during process may volatize VOCs.
		Soil Washing	No	Multiple wastestreams require additional treatment.
		Dechlorination	No	Appropriate for aromatics, not site contaminants.
		Chemical Reduction/ Oxidation	No	Reduced effectiveness for sludge and soils; reduction more appropriate for metals like hexavalent chromium.
		Chemical Extraction	No	Multiple wastestreams require additional treatment.

Table 2-5

SUMMARY OF IDENTIFICATION AND SCREENING OF PROCESS OPTIONS FOR REMEDIATION OF CONTAMINATED SOIL

General Response Action	Remedial Technology	Process Options	Retained for Further Evaluation?	Comments
Treatment (Cont.)	Thermal Treatment	Incineration (rotary kiln)	Yes	None
		Incineration (infrared)	Yes	None
		Incineration (fluidized-bed)	Yes	None
		Pyrolysis	No	Performance data limited.
		Thermal desorption	Yes	None
	Biological Treatment	Slurry-phase	No	Site contaminants not readily degradable, may yield toxic byproducts (i.e., vinyl chloride).
		Landfarming	No	Site contaminants not readily degradable, may yield toxic byproducts (i.e., vinyl chloride).
	In situ Treatment	Vapor Extraction	Yes	None
		Air Sparging	Yes	None
		Soil Flushing	Yes	None
		Vitrification	No	More appropriate for nonvolatile inorganics; high energy vitrification process may volatilize VOCs.
		In situ Bioremediation	No	Site contaminants not readily degradable, may yield toxic byproducts (i.e., vinyl chloride).

Table 2-5

SUMMARY OF IDENTIFICATION AND SCREENING OF PROCESS OPTIONS FOR REMEDIATION OF CONTAMINATED SOIL

General Response Action	Remedial Technology	Process Options	Retained for Further Evaluation?	Comments
Disposal	Off-Site Disposal	Landfill (off site)	Yes	None
	On-Site Disposal	Landfill (on site)	No	Shallow water table and active use of site as railyard would not allow RCRA hazardous waste landfill criteria to be met.

Source: Ecology and Environment, 1994.

Table 2-6

SUMMARY OF IDENTIFICATION AND SCREENING OF PROCESS OPTIONS FOR REMEDIATION OF CONTAMINATED GROUNDWATER

General Response Action	Remedial Technology	Process Options	Retained for Further Evaluation?	Comments
No Action	Not applicable	Not applicable	Yes	May be used as baseline comparison.
Additional Investigation	Groundwater sampling, information searches	Monitoring well installation, sample collection/analysis	Yes	May help delineate additional source areas, enhance effectiveness of overall remedial efforts.
Institutional Actions	Access Restrictions	Deed Restrictions	Yes	Does not reduce contamination but reduces exposure potential.
	Monitoring	Groundwater Monitoring	Yes	Does not reduce contamination, but effective in assessing site conditions.
		Air Monitoring	Yes	Determine need for vapor abatement in buildings above contaminant plumes.
	Use Restrictions	Alternate Water Supply, Well Abandonment	Yes	Does not reduce contamination, but eliminates most significant exposure pathway.
Vapor Abatement	Sealing Floors/ Basements	Grouting	Yes	Effective in reducing vapor migration into buildings.
	Building Venting	Fan/blower	Yes	Effective in reducing vapor accumulation.
Containment	Cap	Multimedia Cap	No	Shallow water table and relatively permeable soil reduce effectiveness.; implementation difficult because of tracks and active use of the railyard.
	Vertical Barriers	Slurry walls/sheet piling/grout curtain	No	Shallow water table and deep confining layer reduce effectiveness; implementing difficult because of tracks and active use of the railyard collection GRA technologies may achieve containment.

Table 2-6

SUMMARY OF IDENTIFICATION AND SCREENING OF PROCESS OPTIONS FOR REMEDIATION OF CONTAMINATED GROUNDWATER

General Response Action	Remedial Technology	Process Options	Retained for Further Evaluation?	Comments
Collection	Extraction	Extraction wells	Yes	None.
	Subsurface Drains	Interceptor trenches	No	Contamination too deep for trenches to be effective.
Treatment	Physical/Chemical Treatment	Sedimentation	Yes	Not necessarily effective in the direct treatment/removal of site contaminants but may be needed to enhance overall performance of primary treatment options.
		Filtration	Yes	Not necessarily effective in the direct treatment/removal of site contaminants but may be needed to enhance overall performance of primary treatment options.
		Air Stripping	Yes	None.
		Reverse Osmosis/ Ultrafiltration	No	More appropriate for removal of ions such as metals.
		Oil/Water Separation	No	Not appropriate for site contaminants.
		Precipitation	Yes	Not necessarily effective in the direct treatment/removal of site contaminants but may be needed to enhance overall performance of primary treatment options.
		Ion Exchange	No	Appropriate for ions such as metals, not site contaminants.
		Chemical Reduction	No	Appropriate for reduction of metal ions such as hexavalent chromium, not site contaminants.

Table 2-6

SUMMARY OF IDENTIFICATION AND SCREENING OF PROCESS OPTIONS FOR REMEDIATION OF CONTAMINATED GROUNDWATER

General Response Action	Remedial Technology	Process Options	Retained for Further Evaluation?	Comments
Treatment (Cont.)	Physical/Chemical Treatment (Cont.)	Chemical Oxidation	No	More applicable to cyanide and oxidizable organics, not commonly used to treat chlorinated VOCs.
		Activated Carbon Adsorption	Yes	Additional effectiveness for treating primary treatment effluent and vapor emissions to meet effluent and emission standards.
		Ultraviolet Photolysis/ Ozonation	Yes	None.
		Dechlorination	No	More appropriate for aromatics, not site contaminants.
		Chemical Neutralization/ Detoxification	Yes	Not necessarily effective in the direct treatment/removal of site contaminants but may be needed to enhance overall performance of primary treatment options.
	Biological Treatment	Fixed-film bioreactor	No	Site contaminants not readily degradable, may yield toxic byproducts (e.g., vinyl chloride).
		Activated sludge	No	Site contaminants not readily degradable, may yield toxic byproducts (e.g., vinyl chloride).
	Thermal	Supercritical oxidation	No	Requires large amounts of energy; more appropriate for concentrated waste-streams.

Table 2-6

SUMMARY OF IDENTIFICATION AND SCREENING OF PROCESS OPTIONS FOR REMEDIATION OF CONTAMINATED GROUNDWATER

General Response Action	Remedial Technology	Process Options	Retained for Further Evaluation?	Comments
Treatment (Cont.)	*In situ* Treatment	Air sparging	Yes	None.
		Steam injection	Yes	None.
		Enhanced biodegradation	No	Site contaminants not readily degradable, may yield toxic byproducts (e.g., vinyl chloride).
Disposal	Discharge	Aquifer reinjection	Yes	None.
		Discharge to POTW	Yes	None.
		Deep well injection	No	Appropriate geologic conditions are not present at site.
		Discharge to surface waters	Yes	None.

Source: Ecology and Environment, Inc. 1994.

Table 2-7

SUMMARY OF *IN SITU* AIR SPARGING/VAPOR EXTRACTION CASE HISTORIES

Site Description	Initial Contamination Levels	Site Geology	Air Sparging/Vapor Extraction System	Results
Solvent contamination from unknown source[a]	2,800 mg/kg TCE and 64 mg/kg PCE[c] in soil; 33,000 ppb solvents in groundwater	110 feet of sand and gravel; silty sand layer at 44-47 feet from surface; 27 feet from surface to groundwater	Two vapor extraction units (475 cfm) removed 5,100 pounds of solvents in 100 days. On day 100, air injection began (five 37-foot-long pipes at 6 cfm each)	8,900 pounds of solvents removed within 240 days; groundwater concentration reduced to 270 ppb solvents
Solvent degreaser leak[a]	Two downgradient groundwater monitoring wells contained 1,200 ppb and 230 ppb TCE[b], respectively, following pump-and-treat remediation	2 feet of fill, 6-7 feet of sandy and clayey silts, and 10 feet of sandy gravel (aquifer) underlain by silty/sandy clay	Five air injection wells installed within 30-foot radius of a soil venting point	Downgradient TCE concentrations reduced to 23 ppb and 10 ppb within two months
Chemical manufacturing site[a]	5,400 ppb solvents in groundwater	Sandy gravels to depth of 36 feet underlain by clays; 8 feet from surface to groundwater	Eight air injection wells installed near soil venting systems	Groundwater solvent concentration reduced to 320 ppb in nine months and <10 ppb in four years
Gasoline spill[b]	19,000-29,000 ppb BTEX in groundwater following five years of pump-and-treat remediation	Fine to coarse sand to depth of 19-20 feet underlain by dense fine sand; 16 feet from surface to groundwater	Seven shallow and six deep air injection wells installed (2-6 cfm each)	5-10 pounds hydrocarbons removed within 60 days; groundwater concentration reduced to nondetectable levels in two to three weeks

Table 2-7 (Cont.)

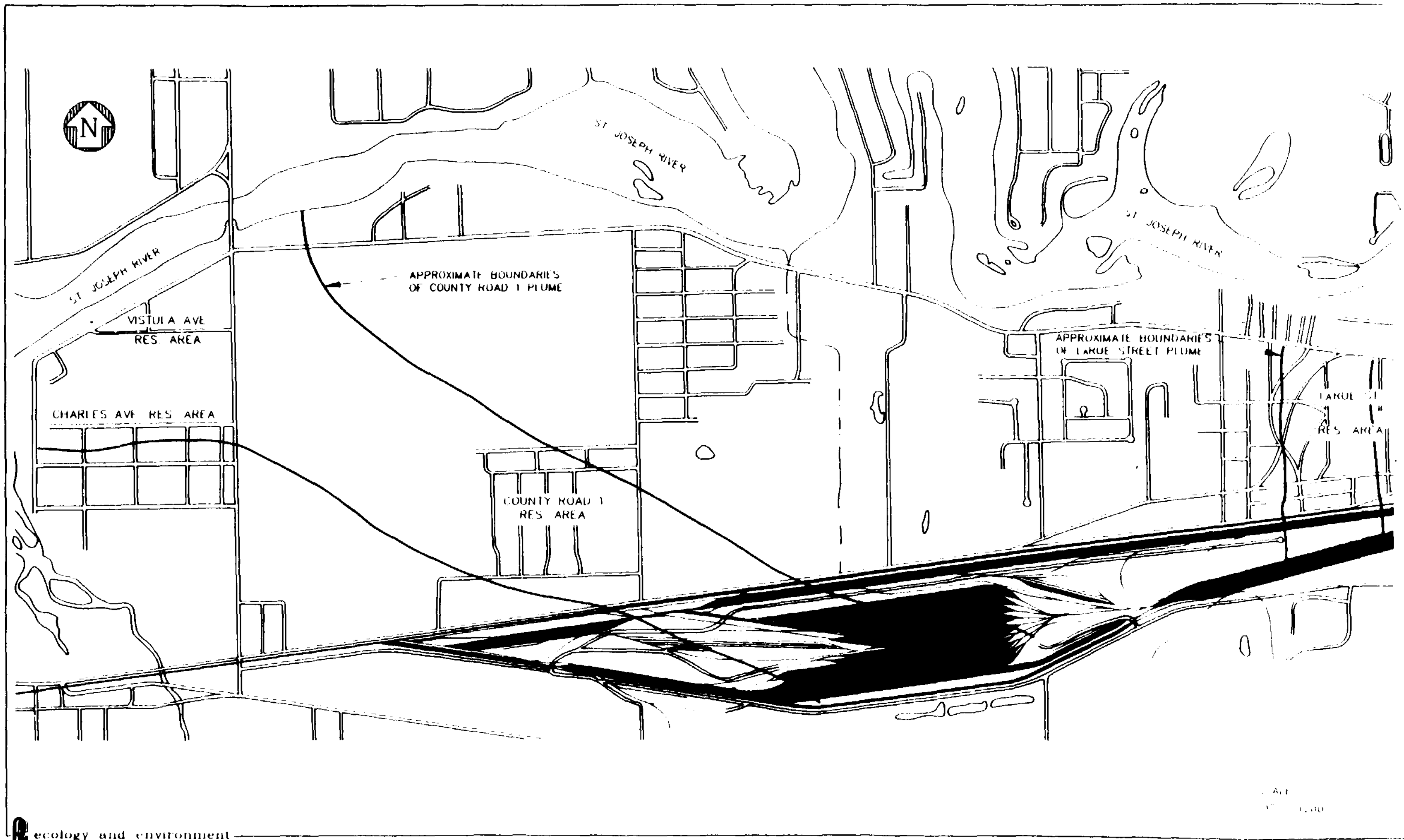
Key:

CFM = Cubic feet per minute.
TCE = Trichloroethylene.
PCE = Tetrachloroethylene.
BTEX = Benzene, toluene, ethylbenzene, and xylene.

[a] From: A.C. Middleton *et al.*
[b] From: M.C. Marley *et al.*

Source: *The Hazardous Waste Consultant* March, April 1991.

ZF3FSFIGS



ecology and environment

FIGURE 2-1 APPROXIMATE EXTENT OF GROUNDWATER

3. DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, representative technologies selected in Section 2 for each medium of concern (soil and groundwater) are further evaluated and combined into alternatives comprehensively addressing contamination for each medium. Consistent with the NCP (40 CFR 300.430), the following range of alternatives was developed:

- The no action alternative;
- Alternatives that remove or destroy the contaminants of concern to the maximum extent possible, thereby eliminating or minimizing the need for long-term management;
- Alternatives that treat the principal contamination concerns but vary in the degree of treatment employed and long-term management needed; and
- Alternatives that involve little or no treatment, but provide protection of human health and the environment by preventing or minimizing exposure to contaminants through the use of containment options and/or institutional controls.

In addition, the NCP specifies that for remedial actions addressing groundwater contamination, alternatives with different remedial time frames should developed. The alternatives developed herein provide a range of remedial time frames.

In Subsection 3.1, technologies and process options retained from Section 2 are combined to form an appropriate range of alternatives for soil and groundwater remediation. Developed alternatives are subsequently evaluated and screened in Subsections 3.2 (for soil) and 3.3 (for groundwater), with regard to the following criteria:

- Effectiveness - short-term and long-term effectiveness and reductions achieved in toxicity, mobility, and volume;

- Implementability - technical and administrative feasibility; and

- Cost - relative capital and O & M costs.

This screening is intended to eliminate alternatives that do not warrant further evaluation because they would not be effective, would not be implementable, or would incur grossly disproportionate costs compared to other alternatives that would achieve a similar level of protection. The screening process reduces the number of alternatives that will undergo detailed analysis in Section 4.

3.1 DEVELOPMENT OF ALTERNATIVES

Remedial action technologies and process options that are not appropriate for site conditions or that would not be effective in meeting the RAOs, based upon the screening in Section 2, have been eliminated from further consideration at this time. Those technologies and options that have not been retained may be reevaluated in the future, if new information or changing site conditions significantly alter the present understanding of the extent and migration pathways of site contamination (e.g. identification of source areas not found to date). In addition, those technologies that were retained through the evaluation in Section 2, but were not selected as representative process options, may be chosen during the design phase if justified.

The objectives for the remedial action focus on the following medium of concern:

- Source soil contamination areas, and

- Contaminated groundwater.

The process options that have been retained and selected as representative technologies for each media of concern include:

Contaminated soil

- No action,

- Institutional actions:
  - Land use restrictions, and
  - Access restrictions.

- Additional investigation.

- Soil excavation.

- On-site low-temperature thermal desorption.

- Off-site rotary kiln incineration,

- *In situ* vapor extraction,

- *In situ* air sparging, and

- Off-site landfilling.

Contaminated groundwater

- No action,

- Additional investigation,

- Institutional actions:

  - air and groundwater monitoring,

  - access restrictions,

  - deed restrictions,

  - well abandonment,

  - partial hook-up to alternate water supply (for groundwater users whose private wells are impacted by site contamination),

  - full hook-up of all groundwater users in site area to an alternate water supply,

- Vapor abatement,

- Extraction wells,

- Air stripping,

- *In situ* air sparging, and

- Discharge to surface water.

These process options have been retained and selected as representative technologies because they are proven technologies that are suitable for implementation at the Conrail Site. They have been proven effective under similar conditions at other contaminated sites. Technologies have been selected that, either alone or in combination with other selected technologies and options, can effectively meet the RAOs. From the process options discussed above, alternatives have been assembled that address contaminated soil and groundwater.

The alternatives that were developed include the No Action alternative and alternatives that achieve varying degrees of remediation (as defined by the RAOs). These alternatives may be revised, and/or new alternatives may be added if new site information warrants or further evaluation reveals the need to consider other alternatives.

3.1.1 Development of Alternatives for Contaminated Soil

The remedial action alternatives developed for contaminated soils are presented below.

Alternative S-1: No Action

The No Action alternative, while not meeting the RAOs, must be included for evaluation purposes in accordance with the NCP. The No Action alternative is used to establish a baseline against which the other alternatives can be compared. Under the No Action alternative, contaminated soil source areas would be left in their present condition; significant contaminant concentrations would remain in place. The potential for continued migration of soil contaminants to groundwater would not be reduced. Risks posed to workers on the Conrail railyard by VOC vapors arising from soil source areas continue unabated.

Alternative S-2: Institutional Actions; Additional Investigation; Soil Excavation; Off-site Incineration

This alternative and all remaining alternatives include institutional actions in the form of access, and deed restrictions. Six-foot chain-link fences would be installed along the perimeters on the north and south sides of the facility. Warning and No Trespassing signs would be posted on these fences. Restrictions would be placed on the deed for the Conrail facility property to limit any future use of the property to a use that is compatible with site conditions. These restrictions could include, but would not be limited, to the following: no recreational use of the facility property, no borrowing of excavated materials for other properties, no agricultural use of the property, and no residential use. Future commercial use requires capping of all contaminated soils.

Additional investigation is also included in this alternative. Additional investigation could include, but would not be limited to, soil borings, soil sample collection, and sample analysis, as needed, to delineate other suspected sources of groundwater contamination.

Under Alternative S-2, the two areas of soil contamination exceeding cleanup goals, TCE-contaminated soil in the track 65 and 66 area, and CCl_4-contaminated soil in the eastern section of the classification yard, would be excavated. The amount of TCE-contaminated soil requiring excavation is estimated to encompass an area measuring 140 feet by 20 feet and extending to a depth of 6 feet. Excavation of the CCl_4 source area is estimated to encompass a volume measuring 100 feet long by 40 feet wide by 10 feet thick. However, to gain access to this soil, the overlying 18-foot-thick layer of soil, which is not contaminated with VOCs above cleanup goals, would have to be removed. If this overlying layer of soil is determined not to be contaminated, it could be backfilled on site. Since the contaminated soil lies below the water table, an extensive construction effort would be required (e.g., sheet piling, brace supports, dewatering, wet excavation techniques). The excavated contaminated soil would be transported by rail off site to an incineration facility. Any excavation of site soils may affect overlying rail tracks, temporary removal and subsequent replacement of tracks to allow excavation equipment access to the soil. Once excavation is complete, and remaining soils are verified as meeting cleanup goals, clean fill material would be placed into the excavation, compacted, graded, and covered with rail ballast. Affected rails would not be available for rail traffic during excavation/backfilling activities. Source excavation and incineration would provide a permanent means of removing the identified VOC sources in the vadose zone, but would be limited to unsaturated soils.

Alternative S-3: Institutional Actions; Additional Investigation; Soil Excavation; Off-Site Disposal

This alternative is identical to Alternative S-2, except that contaminated soil would not be incinerated. In Alternative S-3, the contaminated soil excavated from the TCE source area and CCl_4 source area would be disposed of at an off-site RCRA-permitted landfill or other sanitary landfill, as appropriate, as either a special waste or a hazardous waste.

Alternative S-4: Institutional Actions; Additional Investigation; Soil Excavation; On-site Thermal Desorption

Alternative S-4 consists of the excavation of VOC-contaminated soil, the institutional actions, and the additional investigation as described under Alternative S-2. However, this alternative would employ on-site thermal desorption for treatment of the soil instead of off-site incineration. Excavated soil would be stockpiled to allow for continuous operation of the thermal desorption unit. The stockpile area would need to be constructed in an area away from the tracks, would be lined and covered to minimize leaching and volatilization of contaminants, and would require a collection system to capture runoff. The stockpiled soil would be fed into a mobile thermal desorption unit to volatilize the VOCs and then destroy them in the gas stream before discharge of off-gasses to the atmosphere. Treated soil may be allowed to be backfilled on site if acceptable levels are attained through the thermal treatment process. Verification of adequate soil treatment would be based on analytical results. If treated soil is not acceptable for backfilling on site, it could be transported off site for landfilling (if acceptable under land disposal restrictions). Unlike Alternative S-2, the excavation, backfilling, and replacement of tracks would not necessarily occur in rapid succession. Excavation and stockpiling of contaminated soil will be performed in a manner that will minimize the loss of contaminants from volatilization. Excavation pits would not be backfilled and the tracks would not be replaced until the remaining unexcavated soil was verified to meet cleanup objectives and the excavated soil was treated.

Alternative S-5: Institutional Actions; Additional Investigation; *In situ* Vapor Extraction

Alternative S-5 includes the installation and operation of an *in situ* vapor extraction system to remove VOCs from contaminated soil in the TCE-contaminated track 65 and 66 source area. The CCl_4-contaminated soil would not be addressed. The number and layout of the vapor extraction wells and the need for surface seals or air injection wells to enhance recovery would be determined in a pilot study. These wells would be connected by a manifold. To control VOC emissions, the vapor extraction system would include a vapor-phase treatment system. The extracted air would pass through an air-water separator, a blower, muffler, a water-cooled heat exchanger if necessary, and a vapor-phase carbon adsorption unit. A heat exchanger may be required to cool the exhaust air to allow for efficient carbon adsorption treatment. The side stream of water generated in the air-water separator and in the heat exchanger in the form of condensate would require further treatment.

This water side stream would be treated along with the extracted groundwater, as described later in the discussion of groundwater alternatives. Although the system could be constructed between existing tracks, rail service on some tracks may be interrupted temporarily during installation of the system. Also, piping would have to be installed connecting the treatment areas to process equipment located in a clear area (not immediately adjacent to the tracks).

Alternative S-6: Institutional Actions; Additional Investigation; *In situ* Vapor Extraction and Air Sparging

This alternative expands on Alternative S-5. In addition to the vapor extraction system that would be installed at the track 65 and 66 area TCE source, another vapor extraction system and an air sparging system would be installed in the track 69 CCl_4 source area. The amount of soil requiring treatment in this source area is estimated to encompass an area measuring 40 feet by 100 feet, at depths from 18 to 28 feet BGS. Significant contamination was not detected in overlying soils (surface to 18 feet BGS). The air sparging system would be used in an effort to remediate the contamination in the saturated zone. The surface of the water table is located approximately 6 feet BGS in this area. All the vapor extraction and vapor-phase treatment system components discussed under Alternative S-5 would be necessary for this alternative as well. The major additions would be the installation of air injection wells and an additional air compressor needed to inject the air into the saturated zone. As with vapor extraction, the number and layout of air sparging injection wells would be determined in a pilot study. Effort must be made to ensure that contaminants mobilized by the sparging system will be captured, either through collection of VOCs by a vapor extraction system in the overlying unsaturated zone, or possibly by operation of a groundwater extraction well immediately downgradient from the sparging system.

3.1.2 Development of Alternatives for Contaminated Groundwater

The remedial action alternatives developed to address contaminated groundwater are presented below.

These alternatives, except for the No Action Alternative, include the use of groundwater extraction wells to collect contaminated groundwater. The approach described in the subsequent paragraphs was used for the purposes of this FS Report in order to estimate the number of wells required to achieve capture of a certain area of groundwater and to calculate the time frames needed to operate extraction systems.

Capture zones for pumping wells were calculated using graphs and equations presented by Javandel and Tsang (1986) and Grubb (1993). The equations that were used to estimate capture zones were:

$$y = Q / (2 \cdot K \cdot B \cdot i)$$

for the radial distance from the dividing streamline to the upgradient divide and

$$x = Q / (2 \cdot pi \cdot K \cdot B \cdot i)$$

for the stagnation point (i.e., the downgradient edge of the capture zone). Q is the pumping rate for the well, K is the hydraulic conductivity, B is the aquifer thickness, and i is the hydraulic gradient. These equations have been taken from Grubb (1993). The unconfined aquifer at the Conrail Site is essentially uniform in thickness at approximately 130 feet. The error associated with assuming the aquifer in the study area is 130 feet thick (the estimated range is 120 to 140 feet in thickness) translates to an error in the capture zone radius of 8 percent.

The factor that causes the greatest uncertainty in the estimation of the size of capture zones is the hydraulic conductivity value. The size of capture zones is extremely sensitive to the hydraulic conductivity because the hydraulic conductivity of the aquifer at the site exhibits large variations. After well installation, the pumping rate for each extraction well may have to be adjusted based on the hydraulic conductivity of the aquifer in the vicinity of that well.

Assuming a hydraulic conductivity of 69 ft/day (geometric mean of E & E's Phase II slug test results), a horizontal hydraulic gradient of 0.002, and an aquifer thickness of 130 feet, and simplifying the equations presented in Grubb (1993) for an unconfined aquifer, the upgradient divide (upgradient of the capture well) is 1360 feet away from the dividing streamline for a 250 gallons per minute fully penetrating pumping well. The stagnation point is 430 feet downgradient from the well. Using the curves presented in Javandel and Tsang (1986), the distance from this well to the border of the capture zone perpendicular to the regional groundwater flow direction is approximately 700 feet. The application of these results requires that they must be used in context with the calculated shape of the capture zone. The simplified notion of a radius of capture does not reflect the calculated geometry of the capture zone. The formulas and type curves utilized correspond to maximum capture zones because they were derived using the assumption of infinite time. Capture zone size increases with increasing duration of pumping (McElwee 1991). The infinite time assumption causes an over estimate of the capture zone size if initial pumping removes water from storage before the system reaches steady state. The equations do not consider the addition of water via rainfall infiltration. If the equations accounted for this source of recharge, the calculated capture zone would be smaller (Grubb 1993). It is assumed that extraction wells screened over the entire thickness of the aquifer would allow uniform removal of groundwater from the entire vertical column of the aquifer.

Remedial time frames for groundwater presented in this FS Report were estimated by using a batch flushing model (EPA 1988). This model was used because it is a simple scenario that is amenable to cost calculations. Nevertheless, this model may not be the most appropriate in simulating the rate at which dissolved contaminant concentrations decrease during active pumping. The model will significantly underestimate the number of pore volumes needed for removal if contaminant concentrations decrease asymptotically as they approach the cleanup goal. The calculation was performed using an initial concentration of 1,000 μg/L of VOC contamination and mean aquifer characteristic values determined during the RI. The calculation predicts five flushes would restore the VOC concentration in groundwater to 4 μg/L, assuming no further release of contaminants from upgradient sources (e.g., from DNAPL). However, because these calculations were based on a simplified site model, and upon the performance of pump-and-treat systems at other Superfund sites, there is not a high level of confidence that five flushes would be sufficient to reduce concentrations to cleanup goals.

Alternative GW-1: No Action

The No Action Alternative, while not meeting the remedial action objectives, must be included for evaluation purposes. The No Action Alternative is used to establish a baseline against which the other alternatives can be compared. Under the No Action Alternative, no efforts would be made to remove the contaminant plume from the aquifer. The plume would continue to expand and contaminants would continue to migrate to surrounding groundwater. Potential human health risks would continue to be posed by volatilization of VOC vapors from groundwater and consumption of contaminated groundwater if the plumes expand past the boundaries addressed by the interim remedial action.

Alternative GW-2: Institutional Actions; Vapor Abatement; Continued Operation of Interim Remedial Action Extraction/Treatment System

This alternative and all remaining alternatives will include institutional actions in the form of access restrictions (physical barriers/signs to limit access to treatment facilities), deed restrictions (prohibiting installation of water supply wells in contaminated areas and limiting future use of contaminated areas), and groundwater monitoring (to track contaminant migration and evaluate the effectiveness of any operating remedial efforts). Alternative 2 would also include any necessary expansion of the alternate water supply system to groundwater users (outside of those being connected under the interim remedial action) whose wells are impacted by site contamination, based on future groundwater monitoring. This alternative, and all remaining alternatives, also would include vapor abatement actions, in the event that significant VOC vapors are found to be accumulating in basements or buildings in the study area. Such actions could include sealing cracks and openings in building foundations, basements, or floors or active venting of buildings/basements. Under Alternative GW-2, the groundwater extraction/treatment that will be implemented under the interim action would be continued indefinitely to contain downgradient groundwater contamination currently migrating northwest from the Conrail railyard (the County Road 1 plume). A system designed to contain this plume based on mean hydrologic values for the site would consist of approximately six extraction wells, pumping at rates ranging from approximately 200 to 500 gallons per minute (gpm), located throughout the plume. Under Alternative GW-2, groundwater would continue to be extracted and treated using air stripping and subsequently discharged to the St. Joseph River. This alternative would not address other areas of groundwater contamination including areas to the northeast of the Conrail railyard (LaRue Street Plume).

Alternative GW-3: Institutional Actions; Vapor Abatement; Continued Operation of Interim Extraction System; Containment of LaRue Street Plume

This alternative includes all the actions discussed under Alternative GW-2 plus the installation of groundwater extraction/treatment system in the LaRue Street area to contain the identified plume. Groundwater containment through extraction wells located in the County Road 1 Plume and the LaRue Street plume would continue as long as necessary to capture contaminant migrating off of the Conrail facility. For the purpose of estimating costs, it was assumed that one well pumping at a rate between 250 and 500 gpm would be sufficient to contain the plume in the LaRue Street area. The extracted groundwater would be treated using an air stripping unit. High levels of iron and manganese found in groundwater during the RI may require treatment to prevent scaling in the air stripper. Pretreatment prior to air stripping could consist of precipitation in a sedimentation basin followed by filtration or an equivalent process. An NPDES permit would be obtained and the treated groundwater would be discharged to a surface water body, most likely the St. Joseph River. Exhaust air from the air stripper would be treated by vapor-phase carbon adsorption prior to emission.

Alternative GW-4: Expanded Institutional Actions; Vapor Abatement; Groundwater Containment Beneath and Downgradient from Conrail Railyard

Alternative GW-4 would employ groundwater extraction to prevent contamination from migrating off of the Conrail facility as well as to contain contamination downgradient from the Conrail Site. This alternative includes all the actions discussed under Alternatives GW-2 and GW-3 plus the expansion of the alternate water supply and the installation of additional extraction wells on the Conrail facility. The entire site area (i.e., the area bounded by the St. Joseph River to the north, Baugo Bay to the west, the north boundary of the Conrail railyard to the south, and Nappanee Street to the east) would be connected to an alternate water supply, most likely the City of Elkhart municipal system.

The treatment system under this alternative would consist of a single treatment and discharge system for the LaRue Street Plume, the County Road 1 Plume, and the Conrail facility areas. This combined treatment system would employ the same processes described in Alternative GW-3, but would be larger, and would be located in an open area possibly somewhere between the LaRue Street area and the northern edge of the Conrail facility near Crawford Ditch. An NPDES permit would be obtained, and the treated water would be discharged to the St. Joseph River, possibly via Crawford Ditch. If necessary, the ditch would either be modified to minimize erosion, or conduit would be installed along the length of the ditch to the St. Joseph River. The site containment discussed under this alternative would continue indefinitely. For cost estimating purposes, it was assumed that eight wells each pumping at a rate between 200 and 500 gpm would be sufficient to contain identified plumes beneath and downgradient from the Conrail facility.

Alternative GW-5: Institutional Actions; Vapor Abatement; Active Restoration of Downgradient Contamination; Containment of Groundwater Beneath the Conrail Facility

This alternative incorporates all the actions discussed under Alternative GW-4 (except that the alternate water supply could not be expanded to include all groundwater users in the site area) plus additional extraction wells located downgradient of the Conrail facility, in the County Road 1 Plume, intended to actively restore groundwater in these areas. Based on model results, it was assumed that five additional extraction wells located within the identified downgradient plumes, each pumping at a rate between 250 and 500 gpm (yielding a total of 13 extraction wells for this alternative), would be sufficient to restore the downgradient portions of the aquifer within approximately 25 years. The treatment and discharge system for the interim action might be enlarged to accommodate the increased flow or a new treatment and discharge system might have to be constructed. Treatment and discharge would be similar to that described under Alternatives GW3 and GW4.

Alternative GW-6: Institutional Actions; Vapor Abatement; Active Restoration of the Aquifer; Air Stripping/Surface Water Discharge

This alternative incorporates all the actions discussed under Alternative GW-5 plus additional extraction wells in all identified groundwater contamination areas. In an attempt to restore the entire aquifer within the shortest theoretical time frame (estimated at 15 to 25 years), it was assumed that two to four additional 250-gpm to 500-gpm extraction wells would be needed beyond those proposed under Alternative GW-5. This would total 15 to 17 extraction wells. It should be noted that this number of wells is assumed for cost estimating purposes. The exact number of extraction wells, well locations, and flow rates would be refined during the remedial design.

As described under alternatives GW-4 and GW-5, additional treatment and discharge capacity would be built/combined/enlarged as necessary, although the treatment processes (e.g., air stripping) and the discharge conveyance methods would be the same.

Alternative GW-7: Institutional Actions; Vapor Abatement; Active Restoration of the Aquifer; Carbon Adsorption; Discharge

Alternative GW-7 is similar to Alternative GW-6, differing only in that the primary treatment process for collected groundwater would consist of carbon adsorption. Similar pretreatment (e.g., sedimentation, filtration) would be needed to prevent clogging. Vapor-phase carbon units used with air stripping would not be needed, although the liquid-phase carbon would have to be replaced more often, and spent carbon would require proper regeneration and/or disposal.

3.2 SCREENING OF SOIL ALTERNATIVES

The alternatives that were developed for soil are preliminarily screened in this section to ensure that they meet the RAOs developed in Section 2. The alternatives are screened on the basis of effectiveness, implementability, and, to a lesser extent, cost. The alternatives retained as a result of this screening process will undergo detailed analysis in Section 4.

3.2.1 Effectiveness Evaluation

Alternative S-1, No Action, is not effective in the short term or long term in meeting the RAOs (i.e., in protecting human health or the environment). However, this alternative must be retained for evaluation purposes. Alternatives S-2, S-3, and S-4 provide for removal of the soil, and would allow the greatest reduction in contaminant concentrations remaining in the TCE and CCl_4 source areas. Excavation could allow VOCs in exposed soil to volatilize to the atmosphere. Alternative S-3, overall, does not provide for permanent destruction of contaminants because contaminated soil is simply moved from the site to a landfill, although the landfill would provide more protection (i.e., inherently provides better containment of contaminants) than leaving contaminated soils in place untreated. Alternatives S-2 and S-4 would provide permanent destruction of VOCs in excavated soil using off-site incineration and on-site thermal desorption, respectively. Alternatives S-5 and S-6, which both include *in situ* treatment, would also be capable of achieving soil cleanup goals in the TCE source area, but only Alternative S-6 would address the CCl_4 source area. Alternative S-6 would be capable of achieving soil cleanup goals in both identified source areas.

3.2.2 Implementability Evaluation

Alternative S-1 is technically implementable, since it requires no action. Alternatives S-2, S-3, and S-4 would be difficult to implement because of the removal of tracks that would be required to reach contaminated soils. Rail service would be disrupted during excavation and backfilling/compacting activities. Also, because of the sandy nature of site soils, either significant sloping or the installation of retaining walls (e.g., sheet piling) would be required to allow excavation at any significant depth beneath the surface. Also, to excavate soils beneath the water table, significantly complex construction methods would have to be implemented. Dust control measures would have to be used during excavation activities to limit migration of contaminants through air-borne soil dispersion. Also, protective measures would be needed to protect remediation workers from VOCs volatilized as a result of excavation.

The railyard should provide sufficient space for the location of on-site treatment systems for Alternatives S-4, S-5, and S-6, although space requirements for Alternative S-4 would be greater to allow room for soil stockpiles. Also, under Alternative S-4, the time during which the excavation would remain open (and consequently affected tracks would remain out of service) would be greater because of the need to wait for soil treatment and verification sample results prior to backfilling treated soil. Under Alternatives S-2 and S-3, clean fill material could be obtained in advance so that the excavation could be backfilled as soon as all soil exceeding the cleanup goals had been excavated. The disposal of soil at a landfill, under Alternative S-3, could be limited by land disposal restrictions for hazardous waste.

Some difficulties with implementation also exist for Alternatives S-5 and S-6. Some disruption to rail service is inevitable for any remedial response to address the contaminated soil areas. However, the disruption would be significantly less for installation of the *in situ* alternatives (S-5 and S-6) than it would be for excavation (Alternatives S-2, S-3, and S-4). The installation of piping for extracted or injected air under Alternatives S-5 and S-6 could be performed beneath and alongside tracks with minimal disruption. Extra pumping and piping would likely be required under Alternatives S-5 and S-6 (more than for typical *in situ* treatment systems) because of the distance between the treatment systems and the extraction or injection wells.

3.2.3 Cost Evaluation

The cost for Alternative S-2 (excavation and off-site incineration of contaminated soil) would be much greater than that of other alternatives because of transportation and incineration costs. In general, the *in situ* alternatives are less costly than the excavation and treatment alternatives. Moreover, the costs incurred due to rail service interruption would be significantly greater under excavation alternatives (Alternatives S-2, S-3, and S-4).

3.2.4 Retained Soil Alternatives

Of the six alternatives that were developed to address soil contamination, Alternatives S-2 and S-3 can be screened out because of difficulties involved with implementing these options, because of the high costs required to implement Alternative S-2, and because landfilling would not provide a permanent remedy for the VOCs under Alternative S-3. The No Action Alternative (S-1) is retained for detailed analysis for comparison purposes, to establish a baseline against which other alternatives are evaluated. Alternative S-4 is retained, despite the implementation concerns discussed above, because it would provide an effective means of removing contaminated soil and permanently destroying VOCs. Alternatives S-5 and S-6 are retained for detailed analysis because they have been determined to be effective in meeting the RAOs, provide permanent treatment of the two soil source areas, and can be implemented at the site.

3.3 SCREENING OF GROUNDWATER ALTERNATIVES

The alternatives that were developed for groundwater are preliminarily screened in this section to ensure that they meet the RAOs developed in Section 2. The alternatives are screened on the basis of effectiveness, implementability, and, to a lesser extent, cost. The alternatives retained as a result of this screening process will undergo detailed analysis in Section 4.

3.3.1 Effectiveness Evaluation

Alternative GW-1, No Action, is not effective in the short term or long term in meeting the RAOs (i.e., in protecting human health or the environment). However, it must be retained for evaluation purposes.

The institutional action components of the remaining alternatives will be effective in limiting the more significant exposure pathways (groundwater usage). The alternate water supply system, which will be installed under the interim remedial action for the Conrail Site, would be expended, as necessary, under all alternatives (except no action). However, under Alternative GW-4, the supply system would be expanded to encompass the entire site area (as bounded by the Conrail railyard, the St. Joseph River, Nappanee Street, and Baugo Bay) as a preventive measure. By minimizing the potential for human exposure to contaminated groundwater in this area, this alternative would protect groundwater users outside of the currently identified plume that might be impacted by changes in the plume.

Alternative GW-1 does nothing to address the potential risks posed to human health by VOC vapors volatilizing from groundwater and accumulating in buildings or basements within the study area. Potential risks were determined in the risk assessment but are not verified with field results, because no attempt has been made to date to monitor vapor accumulations. However, if significant levels of vapors are present, Alternatives GW-2, GW-3, GW-4, GW-5, GW-6, and GW-7 would address the vapors to limit human exposure.

Alternatives GW-2, GW-3, GW-4, and GW-5 are intended to achieve only certain RAOs. Only Alternatives GW-6 and GW-7 are intended to meet all the RAOs for groundwater throughout the aquifer (e.g., actively reduce contaminant concentrations to cleanup goals). Alternative GW-2 limits further migration of contaminants in the County Road 1 Plume, but does nothing to limit contaminant migration in the LaRue Street Plume. Alternative GW-3 goes one step further, by limiting migration of contaminants from the LaRue Street Plume. However, neither GW-2 nor GW-3 provides any means for actively reducing contaminant concentrations beneath the facility, and therefore these alternatives provide limited reduction in health risks posed to Conrail railyard workers due to volatilization of VOCs from groundwater beneath the Conrail railyard. Alternatives GW-4, GW-5, GW-6, and GW-7 address groundwater contamination beneath the railyard, and, therefore, by actively reducing contaminant concentrations over time, would reduce the risks posed by VOCs volatilized from the groundwater. Alternatives GW-5, GW-6, and GW-7 actually attempt to achieve RAOs within downgradient portions of the aquifer (GW-5) or throughout the Conrail Site study area (GW-6 and GW-7). The ability of any one of the alternatives to achieve the groundwater cleanup goals may be significantly affected by any remaining contaminant sources that have not been identified to date, and by the presence of TCE and CCl_4 DNAPL beneath the site, which is indicated by analytical results from groundwater samples but not yet delineated. (The delineation of DNAPL is extremely difficult to accomplish because of heterogeneities present beneath any site, particularly a site the size of Conrail). In reality, it may not be technically practicable to reach groundwater cleanup goals (MCLs) beneath the Conrail railyard. However, until that is demonstrated, alternatives must still be considered to achieve MCLs throughout the aquifer.

The groundwater treatment technologies included under Alternatives GW-2, GW-3, GW-4, GW-5, and GW-6 (air stripping) and under Alternative GW-7 (carbon adsorption) would both be effective in reducing the concentrations of VOCs in groundwater to levels well below the discharge limitations required by an NPDES permit (for discharge to the St. Joseph River).

3.3.2 Implementability Evaluation

Alternative GW-1 is technically implementable, since it requires no action. The remaining alternatives would not be significantly difficult to implement, requiring standard equipment, materials, and procedures. Sufficient space would have to be either set aside on the Conrail railyard or obtained somewhere else in the study area to locate groundwater treatment facilities. Rights-of-way would also have to be obtained for any piping from extraction well locations to the treatment facility and from the treatment facility to the point of discharge into the St. Joseph River, and for any extensions of the public water supply. None of these issues should be prohibitively difficult to resolve.

3.3.3 Cost Evaluation

Both capital and O & M costs for each alternative increase as the number of extraction wells increases. Costs for other alternative increase in relation to increased protection provided by the alternative. Cost comparison among alternatives is not significant at this point in the evaluation process, with the exception of the costs of Alternatives GW-6 and GW-7. O & M costs under Alternative GW-7 (for liquid-phase carbon adsorption treatment of groundwater) would be significantly higher than the O & M treatment costs under Alternative GW-6 (for air stripping and subsequent vapor-phase carbon adsorption), although the alternatives would provide the same level of protection and would both attain VOC levels below discharge limitations prior to discharge of treated groundwater to the St. Joseph River. The higher O & M costs for Alternative GW-7 are due, in part, to the fact that the vapor phase adsorption capacity of carbon (i.e., the mass of contaminant that can be adsorbed per mass of carbon) can be from 3 to 20 times higher than the liquid phase adsorption capacity (Noonan 1990).

3.3.4 Retained Groundwater Alternatives

Of the seven alternatives that were developed to address groundwater contamination, Alternatives GW-2 and GW-7 can be screened out at this time. Alternative GW-2, intended to achieve containment of contamination downgradient from the Conrail Railyard, does nothing to address contamination in the LaRue Street Area, and the significant risks that have been determined to be posed by that contamination. Alternative GW-7, while protective and effective, provides no benefit over Alternative GW-6, but would require significantly higher O & M costs. The No Action Alternative (GW-1) is retained for detailed analysis for comparison purposes, to establish a baseline against which other alternatives are evaluated. Alternatives GW-3, GW-4, GW-5, and GW-6 are retained for detailed analysis because they meet the RAOs to at least some extent, and they can be implemented at the site. The retained alternatives provide a range of response actions that can be contemplated for implementation at the Conrail Site, as required by the NCP.

4. DETAILED ANALYSIS OF ALTERNATIVES

4.1 INTRODUCTION

In Section 3, alternatives were developed and evaluated for both media of concern at the Conrail Site: soil and groundwater. As a result of that evaluation, alternatives were either retained for further analysis or were rejected. Those alternatives that were retained are herein combined into comprehensive site-wide alternatives, intended to address all of the remedial action objectives established for the site. Table 4-1 presents the remedial components that constitute each comprehensive alternative analyzed in this section.

Comprehensive alternatives are analyzed at this point in the FS, rather than medium-specific alternatives, because of the interactions between soil and groundwater contamination and because of the impact remedial alternatives for one media will have upon other media. Contaminants in saturated soils exhibit complex interactions between the soil particles and groundwater present within the pore space of the soil, and these interactions must be considered when addressing contamination within one medium. The presence at the Conrail facility of soil or DNAPL source areas that continue to release contaminants into the groundwater may have a significant impact on the effectiveness and restoration time frame for any remedial actions targeting solely groundwater contamination. Therefore, to accurately evaluate the effectiveness of a groundwater action, the accompanying soil action must be defined. Also, the implementation of a remedial action for one medium will impact the implementation of a remedial action for the other medium (e.g., air sparging soil in the saturated zone might require groundwater extraction/treatment downgradient to ensure sufficient capture of mobilized contaminants). Therefore, comprehensive alternatives have been developed for the Conrail Site and will be analyzed in detail in this section.

The following subsections present a detailed analysis of each alternative on an individual basis, and then a comparative analysis of the alternatives in which each alternative is contrasted with the other alternatives contemplated for the site. In this section, each comprehensive alternative was developed in more detail than the alternatives presented in Section 3, so that a thorough comparative analysis could be completed. The details presented within this section (e.g., number of extraction wells, well locations, pumping rates) were developed to provide an understanding of the general scope of each alternative and for cost comparison purposes. These details are not intended to be used during the design of a remedial action, since they were developed for conceptual purposes, not design purposes. The actual detailed components of the selected alternative (e.g., number, locations, and pumping rates for extraction wells) would need to be developed during the remedial design phase.

The individual and comparative analyses are based upon nine criteria developed by EPA to encompass the statutory requirements of CERCLA. These criteria are described in Section 300.430 in Paragraph (e)(9)(iii) of the NCP.

Threshold Criteria

The first two evaluation criteria are threshold requirements; any remedial alternative selected must meet these criteria:

- **Overall Protection of Human Health and the Environment.** Alternatives are assessed to determine whether they can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposures to levels established as cleanup goals. Overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

- **Compliance with ARARs.** The alternatives were assessed to determine whether they attain identified ARARs or whether there are sufficient grounds to waive ARARs as described under Section 300.430 paragraph (f)(1)(ii)(C) of the NCP.

Primary Balancing Criteria

The next five evaluation criteria are the primary balancing criteria. These criteria enable comparison between the alternatives to weigh the individual merits of each alternative. Generally, the alternative selected for implementation at a site will be the alternative which satisfactorily meets the threshold criteria and receives the most favorable evaluation based upon the primary balancing criteria:

- **Long-Term Effectiveness and Permanence.** Alternatives are assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors that are considered, as appropriate, include the following:

  - Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

  - Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste. This factor addresses in particular the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment of the potential need to replace technical components of the alternative, such as vapor-phase carbon adsorption units or packing within an air stripping tower; and the potential exposure pathways and risks posed should the remedial action need replacement.

- **Reduction of Toxicity, Mobility, or Volume Through Treatment.** The degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume is assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following:

  - The treatment or recycling processes the alternatives employ and materials they will treat;

  - The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled;

  - The degree of expected reduction in toxicity, mobility, or volume of the waste due to treatment or recycling and the specification of which reduction(s) are occurring;

- The degree to which treatment is irreversible;

- The type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents; and

- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

- **Short-Term Effectiveness.** The short-term impacts of alternatives are assessed considering the following:

  - Short term risks that might be posed to the community during implementation of an alternative;

  - Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures;

  - Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and

  - Time until protection is achieved.

- **Implementability.** The ease or difficulty of implementing the alternatives are assessed by considering the following types of factors as appropriate:

  - Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy.

  - Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions);

  - Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and the availability of prospective technologies.

- **Cost.** Costs included in this draft FS Report are initial estimates. More accurate cost estimates will be provided in the final FS Report. The types of costs that are assessed include the following:

- Capital costs, including both direct and indirect costs;

- Annual operation and maintenance (O & M) costs; and

- Net present value of capital and O & M costs.

Modifying Criteria

The final two evaluation criteria are used to modify the selection of an alternative. These criteria will be assessed after the public comment period that will follow issuance of the Proposed Plan [the precursor to the Record of Decision (ROD)]:

- **State Acceptance.** Assessment of state concerns, including:
  - The state's position and key concerns related to the preferred alternative and other alternatives; and
  - State comments on ARARs or the proposed use of waivers.
- **Community Acceptance.** This assessment includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. This assessment may not be completed until comments on the proposed plan are received.

4.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

Each remedial alternative is described below and analyzed based upon the seven threshold and primary balancing criteria described above. Table 4-1 presents a summary of the remedial components that make up each alternative.

4.2.1 Alternative 1: No Action

4.2.1.1 Description

The no action alternative includes no remedial actions. Even though certain actions will be implemented at the site under the interim action, these actions have not been instituted to date. Therefore, in compliance with the NCP, the no action alternative is developed and evaluated to serve as a baseline for comparison with other alternatives. Under the no action alternative, no efforts would be made to mitigate the effects of or control the migration of contaminants identified at the Conrail Site.

4.2.1.2 Analysis

Overall Protection of Human Health and the Environment

This alternative provides no protection to human health or the environment. The risks posed to human health, as determined during the risk assessment (Section 1.2.5), would continue unabated. The aquifer would not be restored to its original use as a drinking water supply. Contaminants would continue to migrate, uncontrolled, from the facility to downgradient areas, and subsequently into the St. Joseph River. None of the RAOs for the Conrail Site would be met.

Compliance with ARARs

This alternative does not comply with the NCP goal that groundwater that is a current or potential source of drinking water be remediated to MCLs. This alternative does not achieve the cleanup goals, including health-based concentrations, established for the site, which have been identified as ARARs.

Long-Term Effectiveness and Permanence

This alternative does not provide an effective or permanent means of achieving the RAOs. Significant risks would continue to be posed by site contaminants for a long time period. Contaminants from the facility would continue to migrate into the aquifer, and subsequently through the aquifer to the St. Joseph River, for an indefinite time period (estimated at over 1,000 years if DNAPL continues to contribute to groundwater contamination, or 290 years if DNAPL does not contribute to groundwater contamination).

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative includes no treatment and, therefore, provides no reduction in toxicity, mobility, or volume of contaminants.

Short-term Effectiveness

Although this alternative would not exacerbate current health risks posed by contaminants, neither would it reduce those risks in the near future. This alternative provides no short-term effectiveness.

Implementability

This alternative is technically implementable, since it requires no action. However, administratively this alternative will not be acceptable because it does not meet any of the ARARs.

Cost

No costs are associated with this alternative.

4.2.2 Alternative 2: Institutional Actions, Additional Investigation, Vapor Abatement, Partial Groundwater Containment

4.2.2.1 Description

This alternative, and each remaining alternative, includes several institutional actions intended to limit the potential for human exposure to contaminated media. Institutional actions include groundwater and air monitoring, water supply extension and well abandonment, access restrictions, and deed restrictions.

Because groundwater contaminant concentrations will not decrease significantly within a short time frame, regardless of which remedial alternative is selected and implemented at the site, groundwater monitoring must be performed. Monitoring can be used to track contaminant concentrations in groundwater over time to determine if contaminant concentrations are changing within portions of the aquifer or if contamination is expanding into as yet unaffected areas. Groundwater monitoring can also be used to evaluate the effectiveness of on-going groundwater remedial efforts. Such monitoring would consist of the collection and analysis of groundwater samples from monitoring wells at regular intervals, and reporting of monitoring results. For cost estimating purposes, it was assumed that the monitoring system would consist of 30 existing monitoring wells, sampled on a quarterly basis for VOC analysis. Actual groundwater monitoring requirements would likely need to be revised over time based on changes in contaminants concentrations or groundwater flow directions.

In addition to groundwater monitoring, air monitoring would be conducted in buildings and basements within the Conrail Site study area to determine if significant VOC concentrations are accumulating in basements or buildings, and to determine any changes in VOC vapor concentrations in buildings and basements as a result of changes in groundwater VOC concentrations. Air monitoring would consist of sampling with portable analytical equipment capable of detecting contaminants of concern and/or collection of air samples for laboratory analysis for VOCs.

In the event that air monitoring reveals the need for vapor abatement in buildings within the Conrail Site study area, appropriate actions would need to be considered and implemented. Vapor abatement actions could include sealing building floors or basements (e.g., grouting cracks or seams) and/or the installation and operation of venting systems to ensure sufficient air flow to avoid VOC accumulation. The type and extent of actual vapor abatement actions would be specified after the need for action is determined and the types of buildings affected and levels of VOCs are established. Because the need for vapor abatement has not been established, and because the magnitude of any necessary actions cannot be predicted at this time, no costs have been included for vapor abatement for the purposes of this FS Report.

As specified in the ROD for the Interim Remedial Action for the Conrail site, the City of Elkhart municipal water supply system will be extended to affected areas within the Conrail Site study area, to provide a safe, permanent drinking water supply to residences and businesses downgradient from the Conrail railyard. Private wells within the impacted area will be abandoned once the water supply extension is operational. The extension of the municipal water supply to four impacted areas (Vistula Avenue area, Charles Avenue area, County Road 1 area, and LaRue Street area) is being designed, constructed, and maintained for one year, as part of the interim remedial action for the Conrail Site (currently at the 100% design stage). In addition, under this alternative, the water supply would be extended to other groundwater users downgradient from the railyard whose private wells are impacted by site contamination. The decision to further expand the water supply system would be based on monitoring results. As additional users are connected to the water supply system, private wells would be abandoned. This will essentially eliminate human exposure to groundwater contaminants, for areas connected to the municipal water supply, by restricting the pathway of groundwater use. Other institutional controls would be implemented in the form of fencing and access restrictions to limit access to groundwater extraction and treatment facilities, and deed restrictions to limit future use of groundwater and future use of contaminated areas within the Conrail railyard. For cost estimating purposes, it was assumed that 100 additional residences or businesses would require connection to the alternate water supply.

Additional investigation would be performed to delineate suspected source areas at the Conrail Site that have not been identified to date. As a result of those investigations, any newly discovered source areas could be targeted through groundwater extraction/treatment to most effectively capture contaminants from the sources.

Under this alternative, the groundwater extraction/treatment/discharge system currently being designed under the interim action for the site would be operated to contain the County Road 1 Plume identified northwest of the facility. In addition, a groundwater extraction/treatment/discharge system would be installed and operated to contain groundwater contamination identified to the northeast of the facility (the LaRue Street Plume). Groundwater would be extracted by being pumped from approximately seven extraction wells (six in the County Road 1 Plume area and one in the LaRue Street Plume area), treated using air stripping, and discharged (through piping) to the St. Joseph River. Vapor emissions from the air stripping system would be treated using vapor-phase carbon to ensure capture, and subsequent proper disposal, of VOCs. Approximate extraction well locations are shown on Figure 4-1. These locations are provided only for conceptual purposes; actual well locations would need to be selected during the design of the remedial action, and would take into account the locations of extraction wells installed for the interim action. For cost estimating purposes for the FS, it was assumed that each well would be pumped at rates between 250 and 500 gpm, that the treatment facility would be located within the Conrail railyard and that treated groundwater would be discharged to Crawford Ditch and, subsequently, to the St. Joseph River. The actual number and locations of extraction wells, groundwater pumping rates, and location of treatment facilities and discharge lines should be determined during the design phase for the remedial action.

Under this alternative, no attempt would be made to address identified soil contamination and groundwater contamination within the Conrail railyard itself.

4.2.2.2 Analysis

Overall Protection of Human Health and the Environment

The water supply extension component of this alternative would essentially eliminate the potential for significant human exposure to contaminated groundwater for those groundwater users connected to the supply system. This alternative would provide some protection to the environment by limiting further migration of contaminants in the aquifer downgradient from the facility. Contaminants would no longer be allowed to discharge uncontrolled to the St. Joseph River. However, the risks posed to site workers by vapor inhalation (i.e., volatilized VOCs from soil and groundwater) would continue to exist. Soil contamination beneath the facility would continue to contribute to groundwater contamination.

Compliance with ARARs

This alternative would not, within a reasonable time frame, comply with the goal of the NCP to restore aquifers used as drinking water supplies. This alternative would not achieve the cleanup goals for soil and groundwater that have been established as ARARs.

The discharge of treated groundwater to the St. Joseph River must comply with a NPDES permit, but discharge limits would be attainable using air stripping. Air emissions from the air stripping process must comply with state air discharge requirements, and may require an air emission permit. By properly treating the vapor phase emissions using carbon adsorption, the air emissions under this alternative would comply with state requirements. Any residual process material generated by implementation of this alternative (e.g., spent vapor phase carbon) must be regenerated or handled and disposed of properly. Any residuals which fail the Toxicity Characteristic Leaching Procedure (TCLP) test would have to be managed as hazardous waste.

Long-Term Effectiveness and Permanence

This alternative would provide limited effectiveness in controlling future migration of contaminants from beneath the facility or in reducing risks posed to site workers from contamination in soils present at the site. This alternative provides no permanent remedy for the site. However, the thermal destruction of contaminants removed from collected groundwater (through the incineration or regeneration of vapor phase carbon used to remove VOCs from the air emissions from the air stripping unit) would provide permanent destruction of those contaminants.

Reduction of Toxicity, Mobility, or Volume Through Treatment

The mobility of contaminants downgradient from the facility would be decreased by implementation of this alternative. The total volume of contaminants in the environment would be reduced through extraction of contaminants in groundwater. The stripping of contaminants from the groundwater, collection of vapor phase contaminants using carbon adsorption, and the subsequent regeneration of carbon would provide destruction of contaminants.

This alternative would in no way reduce the migration of contaminants from beneath the Conrail railyard or from soil source areas into site groundwater.

Short-Term Effectiveness

The implementation of this alternative would not increase short term risks to human health or the environment during the implementation of the alternative, as long as access to groundwater treatment facilities is restricted to reduce potential for exposure to extracted groundwater. The water supply connection component of this alternative would essentially eliminate the exposure pathway of groundwater usage downgradient from the Conrail railyard for users connected to the system, but would not provide short-term protection to site workers exposed to vapors from contaminated soils and groundwater.

Implementability

The installation of groundwater extraction, treatment, and discharge facilities should be readily implementable. Property access must be obtained to provide sufficient space for these facilities. The materials, equipment, and labor needed to implement this alternative are readily available.

Cost

The capital cost for Alternative 2 is estimated to be $1.3 million, and the annual O & M cost is estimated to be $135,000. The present worth cost for Alternative 2 is estimated to be approximately $3 million.

4.2.3 Alternative 3: Expanded Institutional Actions, Additional Investigation, Vapor Abatement, *In Situ* Soil Remediation, Groundwater Containment

4.2.3.1 Description

This alternative includes the institutional actions, additional investigation, and vapor abatement actions described under Alternative 2 (in Section 4.2.2.1). However, the alternate water supply would be expanded under this alternative to provide service to the entire site area (as bounded by the Conrail railyard, the St. Joseph River, Nappanee Street, and Baugo

Bay) to ensure that residences and businesses downgradient from the railyard do not use contaminated groundwater. This would be a preventive action intended to address the potential for other portions of the aquifer to be impacted by site contaminants. All private wells in this area would also be abandoned.

Under this alternative, soil contamination source areas identified at the site would be addressed using *in situ* treatment technologies. VOC contamination in the TCE source area in the unsaturated zone would be treated using vapor extraction. The CCl_4 contamination in the one saturated source area would be treated using air sparging, in conjunction with vapor extraction in the overlying unsaturated zone.

Contaminated groundwater beneath the facility and downgradient from the facility would be contained using hydraulic gradient control. The extraction system would consist of six wells being installed as part of the interim action, plus approximately one well in the LaRue Street plume and approximately two additional wells within the boundaries of the railyard. Also, an additional extraction well would be installed immediately downgradient from the CCl_4 source area to assist in containing and capturing contaminants mobilized by the air sparging system. Groundwater would be collected using approximately eight extraction wells, primarily to change groundwater flow patterns to restrict further migration of contaminants from the facility to areas downgradient from the facility and to limit any further expansion of groundwater plumes downgradient from the facility, but also to allow treatment of contaminated groundwater. Approximately eight extraction wells would be required, each pumping at rates between 250 and 500 gpm, for a total volume of groundwater extracted of 2,000 to 4,000 gpm [approximately 2,880,000 to 5,760,000 gallons per day (gpd)]. Approximate extraction well locations are shown on Figure 4-2. The groundwater extraction system would be operated to capture the most contaminated portions of the plumes. For cost estimating purposes, it was assumed that extraction would continue for approximately 30 years. If DNAPL or other sources continue to contribute to groundwater contamination, this time frame could be extended. Collected groundwater would be treated using air stripping and discharged to the St. Joseph River, as described for Alternative 2.

4.2.3.2 Analysis

Overall Protection of Human Health and the Environment

The institutional controls (including complete municipal water supply connection within the site area) and any necessary vapor abatement actions implemented under this alternative will effectively serve to eliminate significant health risks posed to receptors downgradient from the Conrail railyard. By containing groundwater contamination, presently unaffected areas of the aquifer and downgradient environmental receptors (e.g., St. Joseph River, Baugo Bay) would be protected from further degradation. Identified soil contamination present beneath the facility would be significantly decreased using *in situ* treatment processes.

Compliance with ARARs

This alternative is intended to comply fully with groundwater quality ARARs. As described for Alternative 2, the discharge of treated water and air emissions from the groundwater treatment system must comply with state requirements; however, this should not pose any significant limitations to implementing this alternative. If necessary, vapor phase carbon adsorption units would be capable of sufficiently treating the air emissions prior to discharge to the atmosphere. As discussed under Alternative 2, residual process materials generated under this alternative must be properly handled and disposed of.

Long-term Effectiveness and Permanence

This alternative does not provide long-term effectiveness in terms of restoring the aquifer to its original use as a drinking water supply. However, a permanent remedy is provided in that all human receptors who could be exposed to contaminated groundwater (i.e., residences and businesses located downgradient from the railyard) would be connected to a permanent, safe water supply system. *In situ* soil remediation would permanently reduce threats posed by soil contaminants, including the potential for further migration of contaminants to groundwater. Treatability testing would be needed to verify the level of effectiveness of the air sparging/vapor extraction processes.

Given the potential at the Conrail Site for the presence of additional sources that have not been identified to date, and that may continue to contribute to groundwater contamination, and the potential for future accidental releases of contaminants resulting from ongoing rail operations. any remedial eff s will have limited success in attempts to entirely reduce contaminant concentrations in groundwater.

Reduction of Toxicity, Mobility, or Volume Through Treatment

The hydraulic control provided by the groundwater extraction system would limit the mobility of contaminated groundwater. Extracted groundwater would be treated to remove VOCs, resulting in a significant reduction in the mass of contaminants present at the site, over time. In addition, this alternative would significantly reduce contaminant concentrations and mass in the two identified soil source areas through *in situ* soil treatment processes. VOCs extracted from these source areas would be captured and thermally destroyed.

Short-Term Effectiveness

This alternative would significantly reduce contaminant concentrations in the two identified soil source areas within a relatively short time frame, thereby reducing human health risks resulting from volatilization of VOCs from these soils. Care must be taken during operation of the air sparging system to ensure that VOC vapors released from the CCl_4-contaminated soil by the sparging process are sufficiently captured and do not migrate into nearby buildings or basements and accumulate at significant concentrations. The operation of a vapor extraction system in the overlying unsaturated soils, and the operation of a groundwater extraction well downgradient from the air sparging system, should provide effective capture of VOCs migrating from the CCl_4 source area. This would need to be verified during treatability testing for the air sparging system. Overall, this alternative should not negatively impact human health or the environment during the construction and implementation phase, as long as proper health and safety procedures are followed during the installation of groundwater extraction wells and the construction and operation of the groundwater treatment/discharge system and the *in situ* soil treatment systems. Even though control of air emissions may not be required to meet state requirements, vapor-phase carbon would be used to treat the air emissions from the groundwater and soil treatment systems to limit the emission of VOCs to the atmosphere.

Implementability

The most significant limitation to implementing this alternative is the presence of active rails on top of contaminated soil areas. Piping, groundwater extraction wells, and soil treatment systems would need to be installed in such a manner as to minimize interruption of rail use. However, this should not present a significant difficulty. As discussed under Alternative 2, the installation of groundwater extraction, treatment, and discharge facilities should be readily implementable. Treatability testing would need to be conducted to verify the effectiveness of air sparging/vapor extraction for the site. Property access must be obtained to provide sufficient space for these facilities. The materials, equipment, and labor needed to implement this alternative are readily available.

Cost

The capital cost for Alternative 3 is estimated to be $5 million and the annual O & M cost is estimated to be $210,000. The present worth cost for Alternative 3 is estimated to be approximately $7.7 million.

4.2.4 Alternative 4: Institutional Actions, Additional Investigation, Vapor Abatement, *In Situ* Soil Remediation, Groundwater Containment Beneath Facility, Groundwater Restoration Off-Facility

4.2.4.1 Description

This alternative includes the institutional actions, additional investigation, and vapor abatement actions described under Alternative 2 (in Section 4.2.2.1) and *in situ* soil remediation described under Alternative 3 (in Section 4.2.3.1).

The groundwater extraction/treatment system for this alternative is similar to that for Alternative 3, differing in that extraction of groundwater downgradient from the facility would be expanded to actively restore to cleanup goals those portions of the aquifer outside of the facility boundary. Approximately 13 extraction wells would be required in all under this alternative, and the total volume of groundwater extracted would be approximately 3,250 to 6,500 gpm (4,680,000 to 9,360,000 gpd). Approximate extraction well locations are shown on Figure 4-3. Based on modeling, groundwater extraction would need to continue for approximately 25 years to achieve cleanup goals outside of the Conrail railyard property boundaries, assuming no further migration of contaminants from source areas.

4.2.4.2 Analysis

Overall Protection of Human Health and the Environment

This alternative would be intended to actively restore the aquifer downgradient from the Conrail facility boundaries by reducing contaminant concentrations to or below cleanup goals. Soil contaminant concentrations would be reduced below cleanup goals in the identified source areas. Risks posed by contaminants would be reduced, although remaining groundwater contaminants beneath the facility would continue to pose risks to site workers through volatilization.

Compliance with ARARs

This alternative is intended to comply fully with groundwater quality ARARs. The injection of air into subsurface soils to sparge contaminants from the saturated zone must comply with applicable state standards. Air emissions from vapor extraction systems must comply with applicable state air emission standards. Other action specific ARARs would be identical to those discussed for Alternative 3.

Long-Term Effectiveness and Permanence

This alternative would provide a permanent remedy for the identified soil source areas and for groundwater contamination downgradient from the facility. The effectiveness of the air sparging system would need to be verified through treatability testing prior to implementation. The continued presence of groundwater contamination beneath the facility, and the possible presence of other sources that have not been identified to date, could allow for contamination to remain above cleanup goals beneath the facility for a significant length of time, and could also lengthen the remediation time frame for the portions of the aquifer downgradient from the facility.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative would significantly reduce the total mass of contaminants present at the site through *in situ* soil treatment and extraction/treatment of large quantities of groundwater. The treatment processes would remove contaminants from the contaminated media and allow for permanent destruction of those contaminants.

Short-Term Effectiveness

Alternative 4 would significantly reduce contaminant concentrations in known source areas within a relatively short time frame, thereby reducing human health risks resulting from volatilization of VOCs from those source areas. Groundwater contaminant concentrations downgradient from the facility would be reduced within a reasonable time frame (estimated at approximately 25 years). The items of concern described under Alternative 3 for the construction/implementation phase also apply to this alternative.

Implementability

The limitations to implementation of the groundwater components of this alternative are identical to those discussed under Alternative 3. Installation of soil treatment systems must be done in a manner as to minimize disruptions to rail service while still allowing placement of systems in optimum locations to effectively treat contaminated soil areas. Horizontal drilling may be required to install injection or extraction pipes for the air sparging or vapor extraction systems beneath rails. However, these obstacles should be able to be overcome, especially compared with physical limitations to soil excavation in these areas.

Cost

The capital cost for Alternative 4 is estimated to be $3 million, and the annual O & M cost is estimated to be $310,000. The present worth cost for Alternative 4 is estimated to be approximately $6.9 million.

4.2.5 Alternative 5: Institutional Actions, Additional Investigation, Vapor Abatement, Soil Excavation and On-Site Thermal Desorption, Groundwater Restoration

4.2.5.1 Description

This alternative differs from the previous alternatives in that it attempts to actively restore the aquifer beneath and downgradient from the facility through groundwater extraction, treatment, and discharge, and it includes excavation and treatment of contaminated soil in identified source areas.

This alternative includes the institutional actions, additional investigation, and vapor abatement actions described under Alternative 2 (in Section 4.2.2.1). Soil source areas would be excavated, instead of being treated *in situ*, and contaminated soil would be treated on site using thermal desorption. Treated soil would be tested to ensure that cleanup goals are met and then backfilled on site. VOCs thermally desorbed from the soil would be captured and subsequently thermally destroyed.

For cost estimating purposes, it was assumed that an additional four extraction wells would be required under this alternative (added to the 13 extraction wells under Alternative 4. The total volume of groundwater extracted was estimated to be 4,250 to 8,500 gpm (6,120,000 to 12,240,000 gpd). Approximate extraction well locations are shown on Figure 4-4. Groundwater extraction would continue for approximately 25 years.

4.2.5.2 Analysis

Overall Protection of Human Health and the Environment

This alternative attempts to provide maximum protection of human health and the environment through removing contaminants from the site. The aquifer beneath the site is restored to the maximum extent practical, within the shortest time frame.

Compliance with ARARs

This alternative is intended to comply fully with groundwater quality ARARs. Soil excavation and treatment using thermal desorption would have to comply with action-specific ARARs.

Long-Term Effectiveness and Permanence

This alternative would result in a permanent remedy for identified soil source areas. Groundwater would also be remediated to the extent practical. There would be no degradation over time after the alternative has been implemented. However, it is possible that some source areas at the facility will remain unidentified and continue to contribute to groundwater contamination. In such a case, the action would not be completely permanent, since groundwater monitoring would have to continue until groundwater contaminant concentrations decreased, eventually, to cleanup goals.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Thermal desorption of VOCs from contaminated soils would reduce the mass of contaminants by destroying VOCs. The groundwater extraction system would limit the mobility of contaminated groundwater. The stripping of VOCs from collected groundwater, and the subsequent destruction of VOCs during carbon regeneration, would provide a permanent reduction in contaminant mass at the site.

Short-Term Effectiveness

The short-term effectiveness of this alternative would be similar to the short-term effectiveness of Alternative 4. The different treatment of soils under this alternative would eliminate concerns regarding vapor migration associated with air sparging, but would require vapor control measures during excavation.

Implementability

The same implementation issues discussed for Alternative 4 related to groundwater remediation are relevant for Alternative 5. The excavation of soil source areas poses several difficulties.

Portions of several tracks would have to be removed to gain access to the soils. Rail service would be disrupted during excavation, treatment, and backfilling of soil. Also, because of the sandy nature of site soils, either significant sloping or the installation of retaining walls (e.g., sheet piling) would be required to allow excavation at any significant depth beneath the ground surface. To excavate soils beneath the water table (i.e., the CCl_4 source area), complex construction methods such as wet excavation or dewatering would be required. Wet excavation techniques typically are not capable of removing all contamination. Dewatering would require the collection, treatment, and discharge of a significant volume of water and would be extremely difficult to implement. Water collected during soil dewatering might be able to be treated using the groundwater treatment system. Dust control measures would have to be used during excavation to limit migration of VOCs through airborne soil dispersion. Also, protective measures would be needed to protect remediation workers from VOCs volatilized as a result of excavation activities.

The operation of a thermal desorption unit on site would require mobilization of a system to the site and startup procedures prior to treating site soil. A portion of the railyard would have to be set aside for operation of the thermal desorption system. Treated soil would require testing to ensure cleanup goals were met prior to backfilling on site. Following treatment of site soils, the thermal desorption unit would be disassembled and demobilized from the site.

Cost

The capital cost for Alternative 5 is estimated to be $5.5 million, and the annual O & M cost is estimated to be $380,000. The present worth cost for Alternative 5 is estimated to be approximately $10.2 million.

4.3 COMPARATIVE ANALYSIS

In this section, each of the alternatives is compared with and contrasted to the other alternatives to determine the relative advantages and disadvantages of each alternative for the Conrail Site. The evaluation criteria used for this analysis are the same two threshold criteria and five primary balancing criteria, described in Section 4.1, used to evaluate the alternatives on an individual basis. Table 4-2 summarizes the results of the comparative analysis.

4.3.1 Overall Protection of Human Health and the Environment

Alternative 1 provides no protection to human health or the environment. Alternatives 2 through 5 provide varying degrees of protection by reducing contaminant concentrations and containing further contaminant migration. Provision of an alternate water supply and well abandonment in portions of the site area, included under Alternatives 2, 4, and 5, will remove the most significant present human health exposure pathway (groundwater usage). Provision of an alternate water supply to the entire area downgradient from the railyard, under Alternative 3, would provide lasting protection to human health in this area, regardless of any future changes in groundwater conditions (e.g., flow direction changes, contaminant concentration increases, or contamination in areas not detected to date). If determined to be necessary as a result of air monitoring results, vapor abatement, under Alternatives 2, 3, 4, and 5, will reduce adverse health risks posed by vapors accumulating in buildings or basements on and downgradient from the Conrail railyard.

Alternatives 1 and 2 do not reduce further migration of contaminants from identified soil areas into groundwater beneath the Conrail railyard, whereas Alternatives 3, 4, and 5, through reduction of contaminant concentrations in the TCE and CCl_4 soil areas, do limit further migration. However, the presence of other sources which may be present at the

Conrail Site but have not been identified to date, and the presence of DNAPL in the aquifer, will impact site groundwater for the foreseeable future. Most likely, these sources that have not been delineated will continue to release VOCs into groundwater beneath the Conrail railyard (and possibly outside of the property boundaries of the Conrail railyard, if DNAPL has migrated significantly), regardless of which alternative is implemented at the Conrail Site. However, by reducing soil contaminant concentrations, Alternatives 3, 4, and 5 will limit further contaminant migration to groundwater from identified soil source areas and will also reduce health risks posed to site workers from VOCs volatilizing from these source areas.

Groundwater extraction under Alternatives 2 and 3 will limit further contaminant migration in the groundwater, but will take considerable time to achieve groundwater cleanup goals (possibly hundreds of years). Alternative 4 more aggressively extracts groundwater from areas downgradient from the Conrail railyard, while limiting further migration of contaminants from the railyard to downgradient areas, and would therefore affect a faster reduction in contaminant concentrations. Alternative 5 more aggressively extracts groundwater from beneath the Conrail railyard, which while it will not necessarily speed remediation of areas downgradient from the railyard (compared to Alternative 4), will lead to faster restoration of groundwater beneath the railyard. However, if DNAPL or other unidentified sources continue to contribute to groundwater contamination, there will be little difference in protection provided by Alternatives 3, 4, and 5.

4.3.2 Compliance with ARARs

Alternative 1 would not achieve the ARARs used to establish RAOs for the site. Alternatives 2, 3, 4, and 5 would all have to comply with the same action-specific ARARs for groundwater extraction, treatment, and discharge. Alternatives 3 and 4 would have to comply with the action-specific ARARs identified for the vapor extraction and air sparging systems. Alternative 5 would have to comply with the action-specific ARARs identified for soil excavation, thermal desorption, and backfilling. Alternatives 2 through 5 each should be able to comply with the action-specific ARARs identified for that alternative. Alternatives 3, 4, and 5 are intended to comply fully with groundwater quality ARARs. Nonetheless, Alternatives 4 and 5, due to more aggressive pumping strategies, would be more likely to achieve groundwater quality ARARs within a shorter time frame.

4.3.3 Long-Term Effectiveness and Permanence

Alternative 1 provides no long-term effectiveness. The reduction in the mass of contaminants remaining in groundwater that is achieved. to varying degrees. in Alternatives 2. 3. 4. and 5. will be permanent. However. a permanent. complete remediation of the site (i.e., reducing contaminant concentrations to cleanup goals for soil and groundwater throughout the site) does not appear to be attainable. under any of the alternatives. within the foreseeable future. Complete remediation would be hampered by the presence of DNAPL and other unidentified sources and by continued operations at the railyard, which could result in future accidental spills. Therefore. whichever alternative is implemented will require long-term monitoring and possible additional remedial action in the future to address changes in the uses of the site or as a result of new information indicating the need for additional action. The extension of the water supply system to the entire area downgradient from the Conrail railyard. under Alternative 3. provides a permanent remedy by eliminating the most significant (in terms of human health risks) exposure pathway, domestic use of groundwater.

Alternatives 3. 4. and 5 provide permanent reduction in contaminant concentrations in the two identified soil source areas. and also permanently reduce risks posed to site workers by VOC vapors volatilizing from these soil areas. The technologies included under Alternatives 2. 3. 4. and 5 all provide for permanent destruction (through regeneration or incineration of vapor-phase carbon from the air stripping and vapor extraction systems. or thermal desorption of contaminants from soil and the accompanying thermal destruction of VOCs) of the contaminants removed from the site.

4.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The soil treatment components of Alternatives 3. 4. and 5 provide for reduction in the volume of contaminants remaining at the site. The groundwater extraction/treatment components of Alternatives 2. 3. 4. and 5 provide for reduction in the volume of contaminated groundwater remaining at the site and also reduce the mobility of contaminated groundwater. although not through treatment. Alternative 2 provides less reduction that Alternatives 3. 4. and 5. and very well may not result in significant decreases in contaminant concentrations in any portion of the aquifer because of continued migration of contaminants from beneath the Conrail railyard.

4.3.5 Short-Term Effectiveness

The institutional actions included under Alternatives 2, 4, and 5 all provide a similar level of protection during implementation of the remedial action. Alternative 3 provides even greater protection by restricting groundwater use throughout the area. The vapor abatement component of Alternatives 2, 3, 4, and 5, should vapor abatement be determined to be necessary, would provide protection to human health in the short term. The reduction of VOC concentrations in the soil areas under Alternatives 3, 4, and 5 provides additional protection not afforded by Alternative 1 or 2. However, care must be taken to ensure that vapors released from the source area due to air sparging do not migrate to and accumulate at significant concentrations in buildings or basements during remedial action under Alternatives 3 and 4.

4.3.6 Implementability

There are no technical limitations to implementing Alternative 1. Alternatives 2, 3, 4, and 5 require installation of conventional groundwater extraction, treatment, and disposal systems. The installation of vapor extraction and air sparging systems under Alternatives 3 and 4 may require modified construction techniques (e.g., horizontal drilling) to maximize the efficiency of the *in situ* systems and to minimize disruption of rail service on the railyard. Excavation of site soils under Alternative 5 poses several implementation problems (e.g., greater disruption of rail service, difficult excavation of saturated soils). Despite these concerns, each of the alternatives should be technically implementable.

4.3.7 Cost

Costs for each alternative increase in relation to the increased protection they provide and in relation to the decrease in the time frame required to achieve cleanup goals. The differences in present worth costs among the alternatives are not disproportionate.

Table 4-1

CONRAIL SITE
ALTERNATIVES FOR DETAILED ANALYSIS

Remedial Component	Alternative Number 1	2	3	4	5
Groundwater monitoring		X	X	X	X
Air monitoring		X	X	X	X
Partial alternate water supply, well abandonment, access/deed restrictions		X		X	X
Complete alternate water supply, well abandonment			X		
Vapor abatement		X	X	X	X
In situ soil treatment			X	X	
Soil excavation, thermal desorption					X
Groundwater extraction/treatment:					
Containment downgradient from railyard		X	X		
Containment beneath railyard			X	X	
Restoration downgradient from railyard				X	X
Restoration beneath railyard					X
Additional investigation		X	X	X	X

Source: Ecology and Environment, Inc. 1994.

Table 4-2 CONRAIL SITE COMPARATIVE ANALYSIS OF ALTERNATIVES					
	Alternative Number				
Evaluation Criteria	1	2	3	4	5
Overall protection of human health and the environment	1	2	4	4	4
Compliance with ARARs	1	2	4	4	4
Long-term effectiveness and permanence	1	2	4	4	4
Reduction of toxicity, mobility, or volume through treatment	1	2	3	4	4
Short-term effectiveness	1	3	5	4	4
Implementability	5	4	4	4	3
Cost	5	4	3	3	2

Rating:

1 - Poor
2 - Fair
3 - Moderate
4 - Good
5 - Excellent

Source: Ecology and Environment, Inc. 1994.

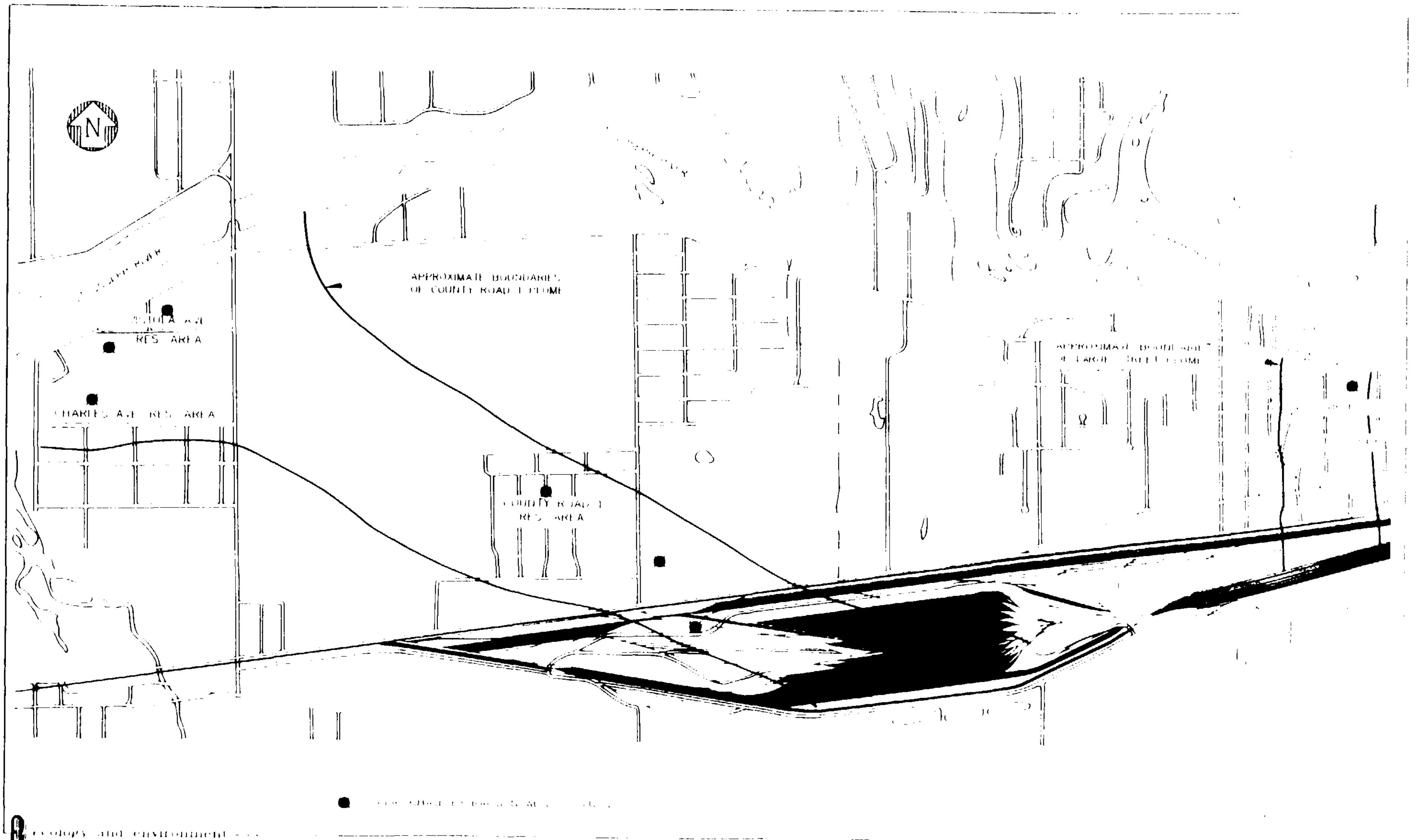


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FIGURE 4-1

ZF3FSFIG2

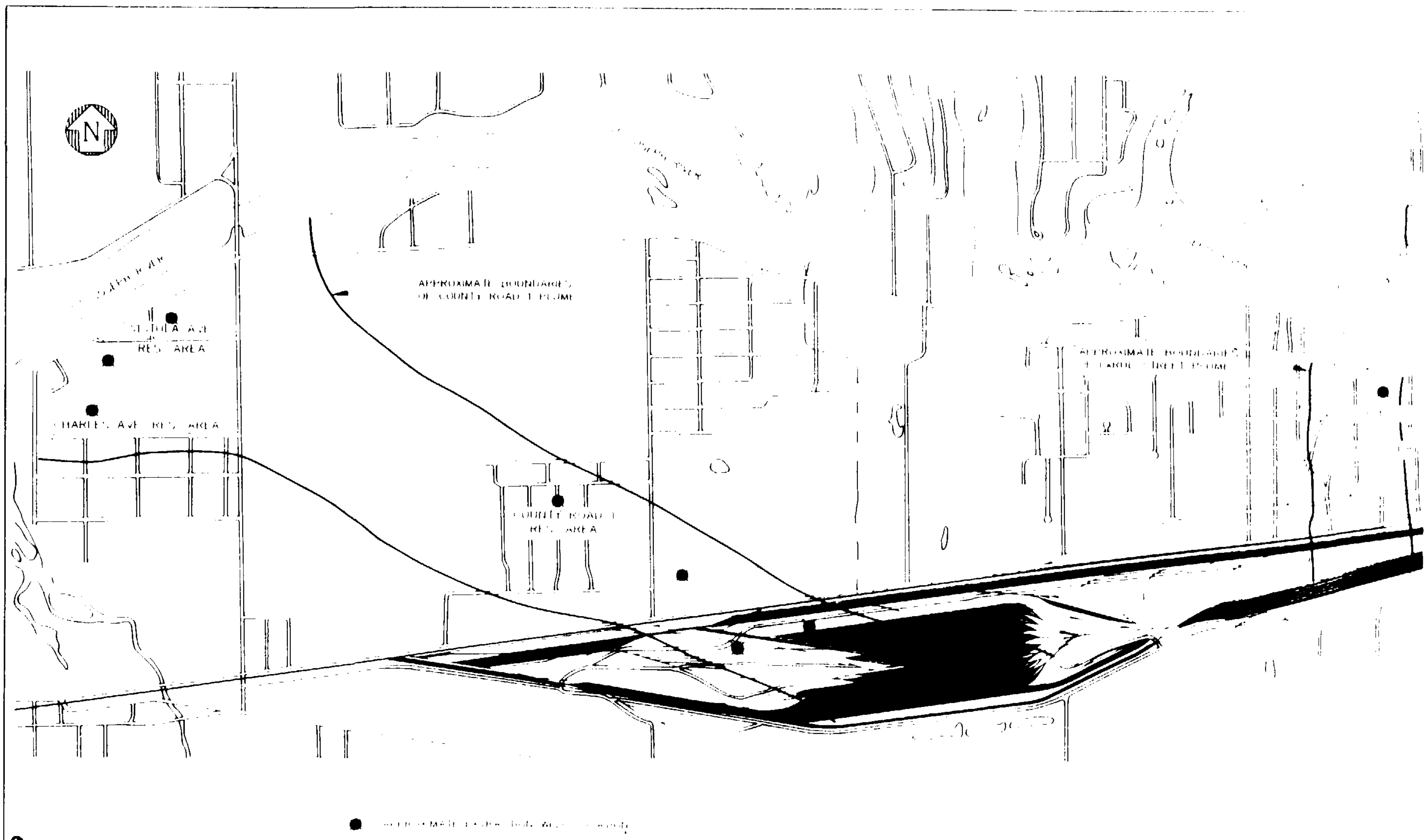

FIGURE 4-2 GROUNDWATER EXTRACTION

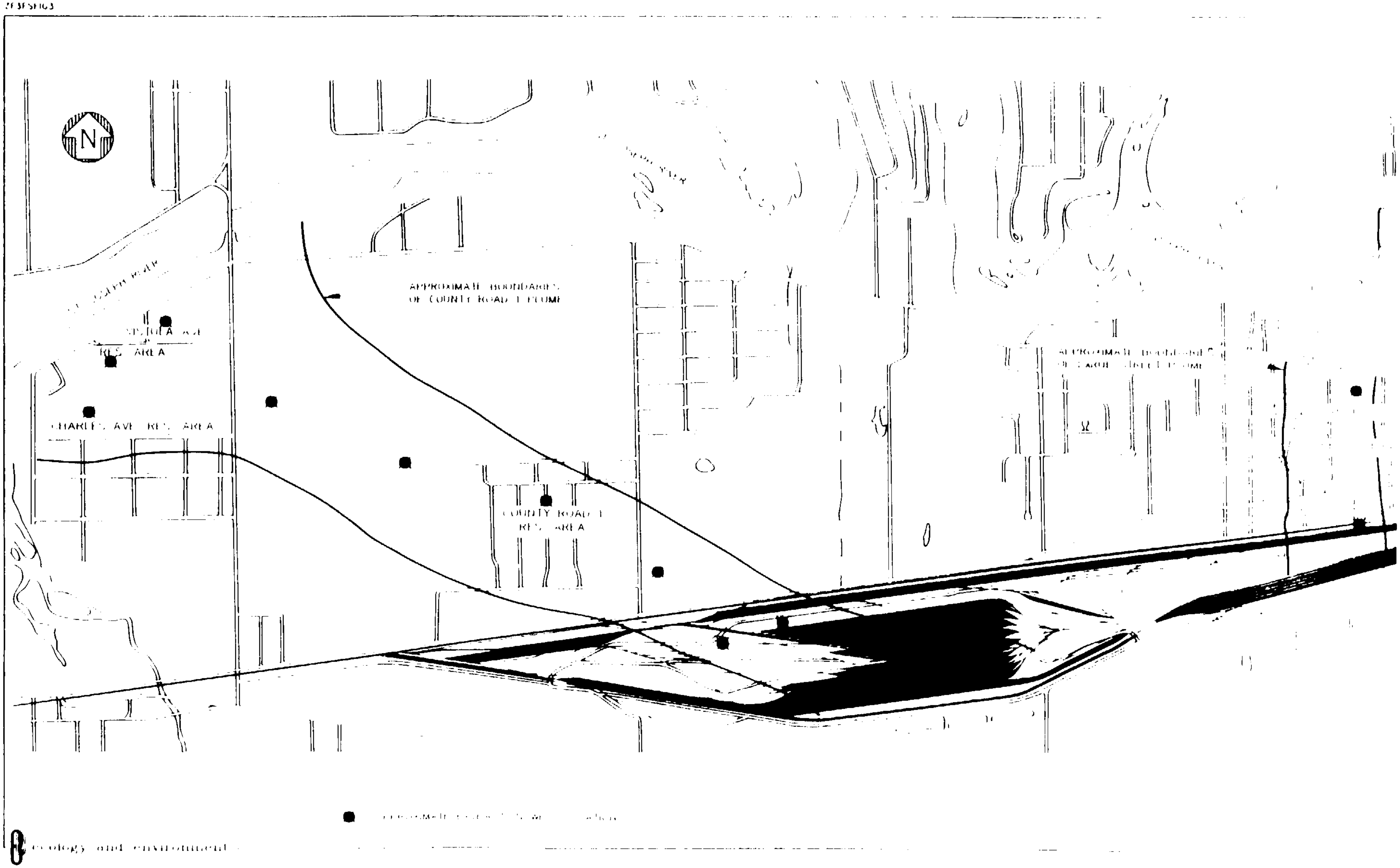

FIGURE 4-3 GROUNDWATER EXTRACTION

ZF3FSFIG4

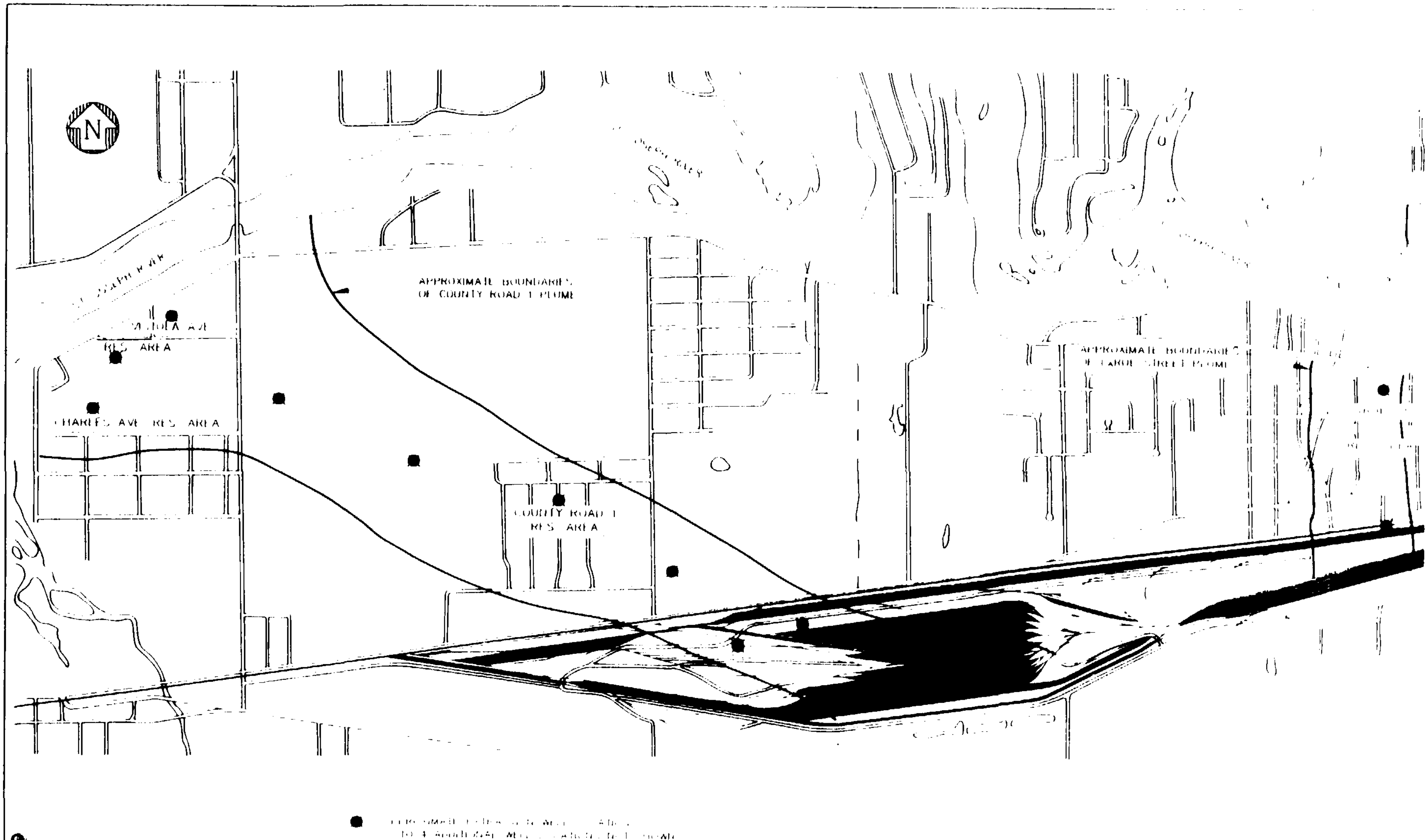

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FIGURE 4-4 GROUNDWATER EXTRACTION

5. FEASIBILITY STUDY SUMMARY

5.1 FINDINGS OF THE REMEDIAL INVESTIGATION

The RI performed by E & E at the Conrail Site confirmed the need for remedial action to address uncontrolled contamination. As a result of past railyard operating activities and/or spills at the site, significant levels of VOCs (primarily TCE and CCl_4) are present in soil and groundwater. Based on the findings of the site-specific risk assessment, contaminants are present at levels that pose significant human health risks and exceed regulatory limits, and therefore remediation is warranted. Specifically, two areas of soil contamination (one TCE source area and one CCl_4 source area) and two plumes of ground-water contamination (the County Road 1 Plume and the LaRue Street Plume) were determined to require remedial action. Contamination from these soil areas and groundwater plumes were determined to pose significant human health risks through the following pathways:

- Volatilization of VOCs from groundwater and soil beneath the Conrail railyard and subsequent inhalation of the VOCs by workers on the facility;
- Use of groundwater from private wells located downgradient from the Conrail railyard, resulting in ingestion of VOCs, dermal contact with VOCs and inhalation of VOCs present in the groundwater; and
- Volatilization of VOCs from groundwater downgradient from the Conrail railyard, migration of vapors into basements or confined building spaces, and subsequent inhalation of VOC vapors.

5.2 REMEDIAL ACTION OBJECTIVES

RAOs and numerical cleanup goals were established to define the objectives of the remedial action, in order to determine what types of remedial responses were appropriate for the Conrail Site and the extent to which remediation needs to be implemented. These objectives were established taking into consideration regulations and guidance (ARARs and TBCs) from federal and state regulatory agencies and the findings of the site-specific human health and ecological risk assessment, which was conducted by E & E as part of the RI, to ensure that cleanup goals will be sufficiently protective of human health and the environment.

The general RAOs that were established for the Conrail Site include:

- Minimizing potential for human exposure to contaminants by eliminating significant exposure routes and/or reducing contaminant concentrations;
- Minimizing further degradation of the groundwater beneath the Conrail facility;
- Minimizing further degradation of the groundwater downgradient from the Conrail facility (outside of the railyard property boundaries); and
- Restoring the groundwater to its original use as a drinking water source.

The following soil cleanup goals were established for the Conrail Site:

- CCl_4 - 5 mg/kg,
- TCE - 3 mg/kg, and
- vinyl chloride - 0.010 mg/kg.

The following groundwater cleanup goals were established for the Conrail Site:

- CCl_4 - 5 μg/L,
- TCE - 5 μg/L,
- 1,1-dichloroethene - 7 μg/L,
- 1,2-dichloroethene - 70 μg/L,
- chloroform - 6 μg/L,
- tetrachloroethene - 5 μg/L, and
- vinyl chloride - 2 μg/L.

5.3 GENERAL RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES

Once the remedial objectives were defined, response actions and technologies that were capable of achieving the RAOs for the Conrail Site were identified and evaluated. Those actions and technologies that were determined to be suitable for addressing site contaminants and that were implementable considering site physical conditions were combined into remedial action alternatives. The actions and technologies that were retained for contaminated soil included: institutional actions, complete water supply hookup, additional investigation, excavation, thermal desorption, incineration, *in situ* vapor extraction, *in situ* air sparging, and off-site landfilling. The actions and technologies that were retained for contaminated groundwater included: institutional actions, additional investigation, vapor abatement, extraction wells, air stripping, *in situ* air sparging, and discharge to surface water.

Each alternative that was developed provided a somewhat different approach to site remediation. Initially, alternatives were developed for each medium, soil and groundwater, separately. Those alternatives that would have questionable effectiveness, that would pose significant technical difficulties during implementation, or that would be disproportionately costly were screened out at this time. As a result, soil alternatives that involved incineration or landfilling and groundwater alternatives that did not address both contaminant plumes or that required higher costs without providing greater protection were eliminated from further consideration. The alternatives that were retained were combined into comprehensive alternatives, addressing the entire site, to undergo detailed analysis. A total of five alternatives were developed and analyzed in detail.

5.4 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The alternatives that were analyzed in detail included:

- Alternative 1: No Action;
- Alternative 2: Institutional Actions, Additional Source Investigation, Vapor Abatement, Partial Groundwater Containment;
- Alternative 3: Institutional Actions, Additional Source Investigation, Vapor Abatement, *In situ* Soil Remediation, Groundwater Containment, Full Alternate Water Supply Hookup;

- Alternative 4: Institutional Actions, Additional Source Investigation, Vapor Abatement, *In situ* Soil Remediation, Groundwater Containment Beneath Facility, Groundwater Restoration Off-Facility; and

- Alternative 5: Institutional Actions, Additional Source Investigation, Vapor Abatement, Soil Excavation and Thermal Desorption, Groundwater Restoration.

The components of each alternative are briefly summarized below.

Alternative 1. No remedial action would be performed under this alternative. This alternative is evaluated to provide a baseline against which other alternatives can be compared. Evaluation of this alternative provides insight into the repercussions of performing no remedial action for the site and allowing site contamination to remain in its present uncontrolled condition.

Alternative 2. Alternative 2 (and Alternatives 3, 4, and 5) would consist of institutional actions intended to limit exposure to contaminated media, additional source investigation, and vapor abatement. The institutional actions would include:

- Provision of an alternate water supply - connection of some areas to existing municipal water supplies and abandonment of private wells in contaminated areas;

- Access and deed restrictions - to limit access to treatment facilities and limit future uses of areas in which contaminants remain; and

- Groundwater and air monitoring - to track contaminant migration in groundwater and determine whether significant levels of VOC vapors are accumulating in basements/buildings in the site area.

Many of these institutional actions will be performed under the interim action for the site. However, the actions will need to be expanded or continued, as necessary, to provide sufficient protection (e.g., groundwater monitoring must also cover the LaRue Street Plume, and air monitoring would have to be added to the scope of the remedial action).

Additional investigations would be performed to attempt to find and delineate source areas that have not been found to date.

Vapor abatement actions, should such actions be determined to be warranted by air monitoring, would include sealing cracks/openings in buildings or basements and/or venting the air from buildings or basements.

Under Alternative 2, the groundwater extraction and treatment system being designed and constructed for the interim action, which is intended to contain the County Road 1 Plume downgradient from the Conrail railyard, would be augmented with an extraction well in the LaRue Street Plume to capture that area of groundwater contamination as well. Extracted groundwater would be treated using air stripping and discharged to the St. Joseph River. This alternative is intended as a containment alternative, and does not provide active restoration of groundwater. This alternative does not address areas of soil contamination identified on the Conrail railyard or the contaminated groundwater beneath the Conrail railyard, although over a long time frame the groundwater beneath the railyard would migrate downgradient and be contained by the downgradient containment systems.

Alternative 3. Alternative 3 would include the institutional actions, additional source investigation, and vapor abatement described above for Alternative 2. This alternative expands the groundwater containment action described for Alternative 2 by the addition of extraction wells within the Conrail railyard to capture groundwater contamination before it migrates downgradient from the railyard. Extracted groundwater would be treated using air stripping and discharged to the St. Joseph River. The distinguishing element of this alternative is the complete connection of the entire site area downgradient from the Conrail railyard to the water supply system, as a preventive measure. Alternative 3 would also address remediation of the two identified soil source areas through *in situ* vapor extraction and air sparging.

Alternative 4. Alternative 4 would include the institutional actions, additional source investigation, and vapor abatement described above for Alternative 2. Alternative 4 would include *in situ* soil treatment as described for Alternative 3. Alternative 4 would also include more extraction wells in the contaminant plumes downgradient from the facility than Alternatives 2 or 3 to actively restore these areas of groundwater. Extracted groundwater would be treated using air stripping and discharged to the St. Joseph River.

Alternative 5. Alternative 5 is similar to Alternative 4, differing in that soil would be excavated and treated on site using thermal desorption. Also, additional groundwater extraction wells [approximately two (if no new sources are identified) to four (if additional sources are identified) more than under Alternative 4] would be installed within the Conrail railyard to more aggressively recover contamination and attempt to restore groundwater beneath the railyard within the fastest practical time frame. Extracted groundwater would be treated using air stripping and discharged to the St. Joseph River.

5.5 EVALUATION OF REMEDIAL ALTERNATIVES

Each of the five alternatives was evaluated individually against the following two threshold evaluation criteria:

- Overall Protection of Human Health and the Environment; and
- Compliance with ARARs;

and the following five primary balancing criteria:

- Long-term Effectiveness and Permanence;
- Reduction of Toxicity, Mobility, or Volume through Treatment;
- Short-term Effectiveness;
- Implementability; and
- Cost.

Following the evaluation of each individual alternative, a comparative analysis among alternatives was performed using the same seven evaluation criteria.

As a result of the detailed analysis, it was determined that only Alternatives 3, 4, and 5 meet the threshold criteria of overall protection of human health and the environment and compliance with ARARs. Because Alternatives 1 and 2 do not meet these threshold criteria, they are not acceptable. The five primary balancing criteria were used to distinguish between the three remaining alternatives (3, 4, and 5).

Alternatives 4 and 5 provide a somewhat greater reduction in the volume of contaminated groundwater remaining at the site through extraction and treatment, than the reduction provided by Alternative 3, because of the greater total groundwater extraction rates. However, Alternative 3 provides somewhat greater short-term effectiveness by connecting all potentially impacted groundwater users (i.e., those downgradient from the Conrail railyard) to the water supply, not just users in portions of the area. The installation of *in situ* soil treatment systems beneath rails may require special construction procedures, under Alternatives 3 and 4, but would be more readily implementable than soil excavation and on-site treatment under Alternative 5.

6. CONCLUSIONS AND OPERATIONAL RECOMMENDATIONS

The findings of the RI indicate that contamination at the Conrail Site is quite complex in nature. Widespread groundwater contamination (primarily TCE and CCl_4) appears to have originated from numerous sources within the Conrail railyard. The suspected presence of DNAPL, along with additional source areas not identified, will have significant impact on the effectiveness of any remedial alternative and the remedial time frame estimated for any remedial alternative.

Despite the complex nature of contaminant sources, groundwater extraction as a remedial option should be highly effective in collecting groundwater and controlling hydraulic gradients at the Conrail Site. Significant decreases in contaminant concentrations would be achieved in the soil and groundwater media by the selection of Alternative 3, 4, or 5. By addressing soil contamination, groundwater contamination, and the potential for vapor accumulation in basements/buildings, Alternatives 3, 4, and 5 would provide significant protection to human health and the environment.

Several technical operational issues must be addressed in the design and implementation of any remedial action for the Conrail Site. Most importantly, a groundwater extraction system should be operated as a dynamic system, changing in response to contaminant concentration levels and/or changes in groundwater flow direction resulting from pumping of the aquifer. The groundwater collection system will need to be reevaluated on a regular basis to determine how effective the system is at collecting the desired amount of groundwater and controlling the hydraulic gradient (i.e., sufficient drawdown and capture zones) and to evaluate the performance of the treatment system (i.e., is it reducing contaminant concentrations within a desired time frame). In order to respond to the contaminant variability in the groundwater plumes, extraction and treatment systems should be designed such that the system can be modified to maintain its efficiency for the removal of contaminants over a wide range of pumping rates and contaminant concentrations. Pulsed or adaptive pumping should be incorporated to improve the efficiency of the extraction system, and also to reduce zones of stagnation (i.e. areas between or downgradient from extraction wells where contaminants accumulate as a result of established and unchanging flow gradients) (Hoffman 1993). In summary, the remedial design should provide flexibility while maintaining the scope of the selected remedial action. The performance of any groundwater extraction system must be closely evaluated during remediation, and the results of this evaluation should be used to modify the system to improve its effectiveness and/or efficiency.

7. REFERENCES

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APPENDIX A

GLOSSARY OF TERMS

GLOSSARY OF TERMS

The following definitions pertain specifically to the Conrail Site Feasibility Study and may not be appropriate for other applications.

Adsorbed Contaminant - A chemical that adheres to the surface of aquifer materials or soil particles.

Air Sparging - A technique that volatilizes organic compounds by simultaneously introducing air into the aquifer and extracting soil vapor.

Air Stripping - A process in which volatile organic chemicals are removed from contaminated water by forcing air through the water. The contaminants are volatilized into the air stream. The air may be further treated before it is emitted to the atmosphere.

Batch Flush Volume - (also pore water volume). The volume of an aquifer that consists of the open spaces between the particles of sand or gravel. This open space is occupied by groundwater and is typically 15 to 40 percent of the total volume. One batch flush volume is the volume of groundwater evacuated from the aquifer that equals the pore water volume of the entire capture zone.

Capture Zone - The area of groundwater in the vicinity of a pumping well that will flow into the well during a specified period of pumping time.

Liquid-Phase Carbon Adsorption - A treatment system in which contaminants are removed from water by forcing the water through tanks containing activated carbon, a specially treated material that attracts and holds the contaminants.

Vapor-Phase Carbon Adsorption - A treatment system in which contaminants are removed from air by forcing the air through tanks containing activated carbon, a specially treated material that attracts and holds the contaminants.

Spent Carbon - Activated carbon utilized in a treatment process to the extent that it no longer can effectively adsorb (and thereby remove) contaminants from a medium.

Cleanup Goal - A numerical contaminant concentration that is to be attained by a remedial action.

Alternative Cleanup Goal - A numerical contaminant concentration value that is used as the criterion for successful remediation. It is established for contaminants that cannot be practicably reduced to cleanup goals initially established due to circumstances that are applicable under CERCLA.

DNAPL - An acronym for a dense nonaqueous phase liquid. DNAPL is synonymous with dense immiscible-phase liquid. The term is sometimes used to refer to dissolved or aqueous-phase chemicals that have the potential to form a DNAPL. A DNAPL is typically a liquid hydrocarbon compound and has a higher density and a lower viscosity than water.

Residual DNAPL - Immiscible-phase liquid held in the pore spaces or fractures by capillary tension. The immiscible-phase liquid in residual form cannot be mobilized by reasonable hydraulic forces.

Downgradient - Denotes areas that have a lower water table elevation relative to the reference water table elevation. The slope of the water table causes groundwater to move towards lower elevations. Therefore, wells downgradient of a contaminated groundwater source are prone to receiving pollutants.

Drawdown - The depression of the water table at a pumping well location caused by the withdrawal of water.

Exposure Pathway - A migration route by which contaminants may reach human or ecological receptors (e.g., groundwater used for drinking, soil gas vapors that migrate into homes) and thereby pose a potential hazard.

Extraction Well - (also pumping well or recovery well). A water well having the capacity for withdrawing large amounts of groundwater from an aquifer.

Groundwater Contamination Plume - The zone of groundwater contamination that exhibits dissolved-phase contaminants at concentrations above a specified concentration level. Plume migration is the movement of the dissolved contaminants with local groundwater flow patterns. Plume removal is the removal of the dissolved-phase mass.

Hydraulic Conductivity - The capacity of an aquifer to transmit water. Hydraulic conductivity is expressed in units of velocity and is often the most important parameter affecting groundwater movement and contaminant migration.

Hydraulic Gradient (Control) - Hydraulic gradient is the change in water level over distance measured in the direction of steepest change. Engineering measures can be taken to achieve hydraulic gradient control (e.g., extraction wells, injection wells, subsurface barriers, trenches), thereby artificially controlling the direction of groundwater flow.

Interim Remedial Action - An action taken to mitigate the most significant effects of contamination (e.g., limit further contaminant migration or human exposure to contaminants) prior to full site remediation. This interim action often is conducted concurrently with ongoing studies, and is intended to provide protection on an expedited basis.

Mobile Contaminant - (also aqueous-phase contaminant or dissolved contaminant). A chemical or compound in solution with groundwater and that is transported with groundwater.

Pilot Study - The study of an initial treatment system, which is installed, operated, and carefully monitored to determine its effectiveness and implementability at a site. If successful, the system may be expanded to increase the capacity of the system. The processes initiated during a pilot study may become an integral component of a comprehensive site remedy.

Remedial Time Frame - The estimated duration of a remedial action; the time required to attain remedial action objectives.

Remediation - A course of actions or processes intended to mitigate site contamination and protect human health and the environment.

Unconfined Aquifer - A water-bearing layer of rock, sand, gravel, etc., that will yield groundwater in a usable quantity to a well or spring. The water contained in the aquifer is located in cracks and pore spaces, or between grains, and is termed groundwater. The surface of an unconfined aquifer, called the water table, is overlain by an unsaturated zone.

Upgradient - Denotes areas having a higher water table elevation relative to areas with lower water table elevations. The slope of the water table causes groundwater to move towards lower elevations. Therefore, wells upgradient of a contaminated groundwater source are not prone to receive contamination through the movement of contaminated groundwater.

Vapor Abatement - Measures taken to reduce VOC vapor accumulations in buildings and/or reduce migration of VOC vapors into buildings or basements.

Vapor Extraction - A treatment technology that is used to volatilize organic compounds from the unsaturated zone by passing air through the subsurface. VOCs are extracted from the ground with the circulating air and are captured at the surface.

Volatilization of Dissolved Contaminants - A process by which compounds change from a liquid state to a gaseous state and pass from water into air.

Well Abandonment - The action by which a water well is sealed to prevent use of the well. This is usually accomplished by removing the well casing and filling the well with gravel, cement, or clay. Water well construction and abandonment codes are specified by each state.